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ANNUAL REPORT

OF THE

STATE ENGINEER AND SURVEYOR

125881

OF THE

STATE OF NEW YORK,

FOR THE

FISCAL YEAR ENDING SEPTEMBER 30, 1895.

TRANSMITTED TO THE LEGISLATURE JANUARY 24, 1896.

WYNKOOP HALLENBECK CRAWFORD CO.,
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STATE OF NEW YORK.

No. 62.

IN ASSEMBLY,

JANUARY 24, 1896.

ANNUAL REPORT

OF THE

STATE ENGINEER AND SURVEYOR.

STATE OF NEW YORK:

OFFICE OF THE STATE ENGINEER AND SURVEYOR,
ALBANY, *January* 24, 1896.

To the Honorable the Speaker of the Assembly:

Sir.—I have the honor to transmit my annual report for the fiscal year ending September 30, 1895.

C. W. ADAMS,
State Engineer and Surveyor.

REPORT.

OFFICE OF THE STATE ENGINEER AND SURVEYOR,
ALBANY, N. Y., *January* 27, 1896.

To the Honorable the Legislature of the State of New York:

Since the greater portion of the time, energy and professional skill of this Department continues to be applied to the design and construction of the varied works incident to the care, maintenance and improvement of the State's canals, it seems fitting that the annual report of the work of this Department should give them first consideration.

For many years, despite the earnest warnings and protests of this Department and the entreaties of thousands of our citizens who were interested in and appreciated the importance of the canals, successive Legislatures have steadfastly refused or neglected to inaugurate and intelligently prosecute any truly comprehensive plan for the improvement of the principal canals, in order to put them abreast the times and in fit condition to continue their importance as a factor in our commercial supremacy. To be sure, much money has been spent on their maintenance, but much more would have proven a better investment, for each successive year has seen a growing volume of business, which should normally have sought our canals, diverted to other routes, both by rail and water, which, by reason of more adequate and modern facilities and management have been able to offer inducements which our canals lacked. In the meantime, the structures connected with our canals have degenerated, while the entire system has suffered seriously from time and the elements, aided largely by lack of attention, due to lack of funds required for thorough and proper maintenance.

The year just passed has been another of great commercial stagnation, and though those conditions have improved appreciably over the previous year, it has probably proven the most disastrous to canal interests within the past sixty years, by reason of the ruinous competition of parallel railroad lines and the comparative inefficiency of the canals.

Finally, and since writing my last report, after years of patient waiting, a new day of prosperity seems to be dawning for the canals. The constitutional convention of 1894 favorably considered the matter of canal improvement, and the people commended their action by a majority of 115,353 at the ensuing election. The Legislature of 1895, in obedience to the will of the people thus expressed, promptly took up the subject, and with the approval of Governor Morton, enacted the following law:

GENERAL.—ALL COUNTIES.

LAWS OF NEW YORK.—By Authority.

(Every law, unless a different time shall be prescribed therein, shall not take effect until the twentieth day after it shall have become a law. Section 43, article II., chapter 8, General Laws.)

CHAPTER 79

AN ACT making provision for issuing bonds to the amount of not to exceed nine millions of dollars for the improvement of the Erie Canal, the Champlain Canal, and the Oswego Canal, and providing for a submission of the same to the people to be voted upon at the general election to be held in the year eighteen hundred and ninety-five.

Became a law March 6, 1895, with the approval of the Governor. Passed three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. There shall be submitted to the people of this State at the general election to be held in November, eighteen hundred and ninety-five, the proposition, to be voted upon by the electors of this State, to issue bonds by the State to the amount not to exceed nine millions of dollars, which bonds shall be sold by the State, and the proceeds thereof paid into the State treasury, and so much thereof as shall be necessary expended for the purpose of enlarging and improving the Erie Canal, the Champlain Canal and the Oswego Canal, and the county clerks in the different counties in this State, and all other officers who are now or may hereafter be charged by law with furnishing ballots to the electors at the said general election, are hereby authorized and directed to cause to be furnished a sufficient quantity of ballots both for and against the proposition to authorize the issuing of the said bonds for, and the enlargement and improving of the Erie Canal, the Champlain Canal and the Oswego Canal; the said ballots shall be printed as follows: "For the proposition to issue bonds for the improvement of the Erie Canal, the Champlain Canal, and the Oswego Canal," and "Against the proposition to issue bonds for the improvement of the Erie Canal, the Champlain Canal, and the Oswego Canal." The Comptroller is hereby charged with the duty of selling said bonds to the highest bidder after advertising for a period of twenty consecutive days (Sundays excepted) in at least two daily newspapers in the city of New York, two daily newspapers in the city of Brooklyn, and two daily newspapers printed in the city of Albany,said advertisements to contain a provision to the effect that the Comptroller, in his discretion, may reject all bids made in pursuance of said advertisements, and in the event of such rejection the Comptroller is authorized to readvertise for bids as many times as may be necessary to effect a satisfactory sale.

§ 2. In the event of the adoption of the aforesaid proposition in favor of issuing the said bonds for, and the enlargement of and the improvement of the Erie Canal, the Champlain Canal and the Oswego Canal, by a majority of all the votes cast at the said general election for and against the said proposition, the Comptroller is hereby directed, under the direction of the commissioners of the canal fund, to cause to be prepared the bonds of this State to the amount of not to exceed nine millions of dollars, the said bonds to bear interest at the rate of not to exceed four per cent. per annum, which interest shall be payable semi-annually in the city of New York. Said bonds shall be issued for a period of not more than seventeen years, and shall not be sold for less than par; any premium arising from the sale of the said bonds shall be applied to the sinking fund created for the purpose of paying the said bonds and the interest thereon as the same may become due. The said bonds shall not all be sold at one time, but shall be sold in lots not exceeding four millions of dollars at a time, so as to provide funds for work contracted to be completed or done during the ensuing twelve months. The Legislature shall annually impose a tax of thirteen-hundredths mills upon each dollar of valuation of the real and personal property in this State subject to taxation, the proceeds of which tax, after paying the interest due upon the aforesaid bonds, shall be invested by the Comptroller under the direction of the commissioners of the canal fund, and, together with the interest arising therefrom, shall be devoted to the sinking fund created for this purpose, payment from which shall only be made to the extinguishment of the indebtedness created by the sale of the aforesaid bonds, as the said bonds become due, and for no other purpose whatever.

§ 3. Within three months after issuing of the said bonds the Superintendent of Public Works is hereby directed to proceed to enlarge and improve the Erie Canal, the Champlain Canal and the Oswego Canal; the said improvement to the Erie and Oswego canals shall consist of deepening the same to a depth of not less than nine feet of water except over and across aqueducts, miter sills, culverts and other permanent structures, where the depth of water shall be at least eight feet, but the deepening may be performed by raising the banks wherever the same may be practicable; also the lengthening or improving of the locks which now remain to be lengthened, and providing the necessary machinery for drawing boats into the improved locks and for building vertical stone walls, where in the opinion of the State Engineer and

Surveyor and Superintendent of Public Works it may be necessary. The improvement upon the Champlain Canal shall consist in deepening the said canal to seven feet of water, and the building of such vertical stone walls as in the opinion of the State Engineer and Surveyor and Superintendent of Public Works may be necessary. The work called for by this act shall be done in accordance with plans, specifications and estimates prepared and approved by the State Engineer and Surveyor.

§ 4. All the work herein specified to be done shall be done by contract, entered into by the Superintendent of Public Works on the part of the State, after being advertised once a week for six consecutive weeks in two newspapers in each county in this State, in which any part of the canal is located, and the counties of New York and Kings, and shall be let to the lowest responsible bidder giving such security as the canal board or a majority thereof may require and approve, but in no case shall the amount of any one contract exceed the sum of five hundred thousand dollars. The work so done shall be performed under the direction of the Superintendent of Public Works, upon plans prepared by the State Engineer and Surveyor, which plans and specifications shall state the kind of material to be used, and the quality of the same. The Superintendent of Public Works may at any time before entering into contract for the performance of any part of the said work, and after the bids are opened, cancel all of the bids received for the said work and readvertise and relet the same in the manner above described; he may, also, at any time, with the concurrence of the canal board or a majority thereof, suspend any contract while the work is in progress if, in his judgment, the work is not being performed to the best interests of the State, and may complete the same in such a manner as will be to the best advantage of the State, and any excess in the cost of completing the said contract beyond the price for which the same was originally awarded shall be paid by the contractor failing to perform the work. Every contract entered into by the Superintendent of Public Works and any contractor or contractors shall reserve the right to the said Superintendent to suspend the said contract upon the approval of the canal board or a majority thereof, and to enter upon and complete the same whenever in his judgment the work is not being performed in a suitable manner or to the advantage of the State. Separate plans shall be prepared for each piece of work by the State Engineer and Surveyor, and the extent of each piece of work and quality of material to be used shall be agreed upon by the Superintendent of Public Works and the State Engineer and Surveyor, but no plans shall be altered after the contract is awarded except upon the approval of the canal board or a majority thereof. Each and every contract let as herein provided shall state the gross amount for which the said contract is to be performed, and all bids or proposals received by the Superintendent of Public Works for the performance of any of the work herein described must state the gross amount for which it is proposed to complete the contract upon which the bid or proposal is made, and no extra charge will be allowed except in cases where a change has been made in the original plans and approved by the canal board or a majority of them.

§ 5. The Superintendent of Public Works may, from time to time, upon the certificate of the State Engineer and Surveyor, pay to the contractor or contractors a sum not exceeding ninety per cent. of the value of the work performed, and such certificate of the State Engineer must state the amount of work performed and its total value, but in all cases not less than ten per cent. of the gross amount for which the contract was let must be retained until the contract is completed and approved by the State Engineer and the Superintendent of Public Works.

§ 6. The sum of four millions of dollars is hereby appropriated, payable out of the moneys realized from the sale of bonds as provided by section one of this act, to be expended to carry out the purposes of this act. Said sum of four million dollars to be paid by the treasurer on the warrant of the Comptroller to the order of the Superintendent of Public Works when certified by that officer to be needed from time to time in the promotion of said work.

§ 7. Any surplus arising from the sale of the bonds over and above the cost of the entire work of the improvement of the canals as herein provided for shall be applied to the sinking fund for the payment of said bonds.

§ 8. This act shall take effect immediately.

STATE OF NEW YORK,
OFFICE OF THE SECRETARY OF STATE. } *ss.:*

I have compared the preceding with the original law on file in this office, and do hereby certify that the same is a correct transcript therefrom and of the whole of said original law.

JOHN PALMER,
Secretary of State.

Pursuant to this law the people on November 5 again expressed their determination that the canals should be improved, and the above law has been ratified by a majority of 276,886. As a majority also decided at that time that I should remain in charge of the State's Engineering Department till 1899, a few words concerning this contemplated improvement may not be amiss here, though strictly they are occasioned by a result arrived at since the end of the fiscal year 1895. While the fate of the law just quoted was well known by November 7, 1895, nothing could be done by this Department, except to formulate plans for its better organization, till the funds from the sale of bonds became available, and these could not be advertised for sale till the State board of canvassers had formally declared the result of the vote of the people on this question.

This latter formality was complied with on December 12, just three days prior to the limit prescribed by law, and immediately the Comptroller was prepared to and did advertise $2,000,000 of the new bonds for sale, but prior to the date fixed for the opening of bids, the complications of the Federal Government with Great Britain arose over the Venezuelan boundary, and this, together with the notice of another Government bond sale, resulted in very low bids for these bonds. The total amount sold was $1,770,000, and the premium on same, which is only applicable to a sinking fund for their redemption, amounted to $1,378. This sale of bonds occurred on January 9, and on the following day, as soon as we were assured that the funds would be available, about two hundred assistants from the eligible civil service lists were summoned to report for duty to the respective division engineers on the following Monday. This force, augmented by such other assistants as could be spared from the ordinary work, has been divided into twenty-five separate parties, nine each being assigned to the eastern and western divisions, and seven to the middle division. Each of these parties will cover about eighteen miles, making a total of about four hundred and fifty miles, or the total length of the Erie, Oswego and Champlain Canals, which are to be improved.

It is expected that each of these parties will complete the resurvey and prepare the detailed estimates of cost, of its allotted section, so that about May 1, 1896, this office may be in possession of complete, reliable, detailed estimates of the cost of the entire improvement, so that the preparation of plans for active work can thereafter progress intelligently, and always with the knowledge of what the total cost will be. Under such circumstances, the work can be promptly started at as many points on each of the canals as contracts can be awarded for advantageously.

The several offices of this Department are being reorganized for the work as rapidly as possible, and in this connection I wish to direct the attention of the Legislature to the inadequate condition of the headquarters of this Department, and urge their cooperation in furnishing us with more room in this building, and with sufficient funds to put our present available space in fit condition for the work in hand. Many repairs to our quarters have been made that have added very materially to their utility and appearance, and many of our records have been overhauled, and the antiquated system of indexing the same has been somewhat improved, but there are still thousands of documents to be overhauled, classified and indexed properly, and I urge that an appropriation for this work be made available at once. The work has already been too long delayed, and the usefulness of the Department to the people of the State is therefore sometimes seriously interfered with.

There are some provisions of the law in question which should be changed in order that the work can progress more rapidly than would be possible under the terms of the present law. I refer to the provisions of section 4, which provides that each and every contract to be awarded shall be "advertised once a week for six consecutive weeks in two newspapers in each county of this State in which any part of the canal is located, and the counties of Kings and New York."

This seems to be altogether a useless and expensive provision, for it involves advertising every piece of work, however small, in at least thirty-eight newspapers, and it will be found that the cost of such advertising will be altogether out of proportion to the cost of the work, while the duration of time required for advertising will be found equally as great an objection. For instance, there are quite a number of small structures that will certainly have to be repaired or remodeled in order to do the work required of them, and a great many of these jobs are so small that it should be possible for us to advertise the same, award the contracts and have the work completed before the opening of navigation next spring, but it will be found impossible to do so if six weeks of the intervening time is wasted in advertising. In this age of daily newspapers ten days or two weeks at the outside, is ample time in which to advertise this work, and I urge that the law be amended in this respect, and also that the newspapers in which the work shall be advertised, in addition to the so-called State paper, shall be left to the discretion of the Superintendent of Public Works. Practically that puts this feature of the new work in the same routine which has for years been followed in connection with all other public work done by the State on the canals, and I have yet to learn that any serious fault has been found with former methods in this line.

Another provision of this law which is far more objectionable than the features above mentioned, and which I believe must be changed if the work is to be prosecuted in a rational, economical and business-like manner, is the latter part of section 4, which says: "Each and every contract let as herein provided shall state the gross amount for which the said contract is to be performed, and all bids or proposals received by the Superintendent of Public Works for the performance of any of the work herein described must state the gross amount for which it is proposed to complete the contract upon which the bid or proposal is made, and no extra charge will be allowed except in cases where a change has been made in the original plans and approved by the canal board, or a majority of them."

At first glance this would seem to most people to be a reasonable and safe provision for so great an undertaking, but on closer investigation it will be found to be decidedly impracticable. In the case of a bridge, culvert, waste-weir, or other small structure and possibly with the lengthening of any of the locks, it might be possible to enumerate each and every little item that would go to make up the total cost of the work with such great care that our estimates of cost would conform very closely to the bids of the contractor. But it must be borne in mind that in order to have this great work completed expeditiously that a large portion of the work must be contracted for in long sections, and it will be found impracticable, if not impossible, to prepare the plans and engineer's estimates for one of these long sections of work so closely that absolutely no changes would be required either in the manner of doing the work or in the amount of same. To prepare such plans and estimates would take a very large and unwarranted force of men many months and would cost a ridiculous sum of money.

For a great many years the Canal Law has directed what the practice of this Department should be in relation to these matters, and I believe such practice has resulted advantageously to the State, while at the same time protecting the interests of the contractor, and carefully guarding the performance of the work or the management of the finances for the same. Why not adhere to methods which have been proven satisfactory?

What good will be accomplished by the lump sum bids? At present our practice is to prepare an estimate of the cost of each item connected with any of the various pieces of work, and this estimate is then filed with the Superintendent of Public Works, together with copies of the plans for the performance of the work. From this estimate he prepares so-called bidding sheets, which are submitted to the contractors in order that the bids may be on a uniform basis for comparison. Prices are named for each of the various kinds of work which are required to complete the whole job, and the contractor is paid only for so much of each kind of work as is actually done. Could anything be more equitable? Now, if this system is changed, our plans must necessarily show down to the minutest detail, the quantity of each and every kind of work to be done on any given job. The contractor will submit his bid on that basis, and it is only fair to assume that he will add a sufficient margin for contingencies.

Now, if any additions are made to the quantities bid for, it is pretty safe to assume that the contractor will demand, and undoubtedly recover, the additional cost of such work, while if the quantities for any reason should be less than the amount estimated, it is doubtful if the State's interests can be properly protected.

Another reason why this feature of the law should be changed is that no permanent record of the several quantities of work actually done on any given section are either suggested or required; the inference being that the contract and the final account for the work would simply read for the completion of any given section and a lump sum of money. The present law requires that all work done be itemized and properly recorded for future reference, and such records are very valuable.

Undoubtedly there will be numerous appropriations for the betterment of the canals during the time in which the improvement contemplated under the law in question is progressing, and they will be done in accordance with the old laws. Would it not be better to have all these operations carried on on a uniform basis and in accordance with the law that has proven in every way to be worthy, equitable and adequate?

In a general way there is still another reason for changing this feature of the law in question, and that is that there is probably not an important piece of public work now under way in this country that is being done on the plan outlined by the law, but in nearly if not quite in each and every case investigation will show that the estimates, bids and final estimates are made and the work done on substantially the same lines that have been in use by this Department and that of the Superintendent of Public Works for many years past.

In conclusion of this argument, I wish to add that it is rarely the case that the proposals received for doing State work exceed the estimates of this Department.

It is altogether too early to make any predictions as to the date of completion or probable cost of the improvement contemplated, but the constant and best energies of this Department can be relied upon for their speedy completion, and if it be at all possible, within the amount appropriated.

It should, however, be borne in mind, that the nine million dollars appropriated by this law, is not available for making many improvements which are urgently needed on the canals, which are to be improved under its provisions, and also that none of it is available for the other, but less important. canals of the State, and therefore numerous other appropriations for the betterment of the canals will be required and should be made, as has been the custom for many years.

In providing for the enlargement of the canals by appropriating nine million dollars therefor, the repair of existing structures was evidently not considered, and it is doubtful whether any part of that appropriation can be used for repairs not pertaining directly to the canal prism. For this reason the accompanying photographs of Erie Canal bridges Nos. 39 and 42 are presented to show, more clearly than can be done by words, the condition of some of the canal bridges. It can easily be seen from the photographs that the bridge abutment which is bound up with timbers is quite liable to fall into the canal and stop navigation completely until it is removed, as well as block the highway.

There are many other bridges in fully as bad condition as those shown, and unless some provision for their renewal is made at once, the canal traffic must remain in constant danger of accidental delays which will more than counterbalance the good results expected from the proposed enlargement.

Many of the feeder dams are badly in need of repairs, and it is especially important at this time that all the dams be put in proper condition in order that the increased amount of water, which the canals will surely need, can be made available when wanted. Many of the feeders and their bulkheads are in a badly dilapidated condition, and should be promptly repaired. There are a great many bridge abutments that are almost ready to topple over into the canals, carrying the bridges with them, and threatening the uninterrupted traffic of the canals.

The reports of the several division engineers hereto appended convey detailed information as to the amount and kind of such work, and it is to be hoped that the recommendations therein contained may promptly be crystalized in the form of laws.

LOCK LENGTHENING.

The so-called canal improvement bill provides for "lengthening or improving all the locks which now remain to be lengthened, and providing the necessary machinery for drawing boats into the improved locks" on the Erie and Oswego Canals.

Forty of the seventy-two Erie locks have already been lengthened, and the remaining thirty-two cannot be improved in the manner heretofore adopted, because their respective locations do not admit of such treatment. Some radically different design is needed in order to improve the remaining locks which are located as follows:

Nos. 3 to 18 inclusive, between West Troy and Cohoes; Nos. 21 and 22 at the north end of the Upper Mohawk aqueduct; Nos. 36, 37, 38 and 39 at Little Falls; Nos. 57, 58 and 59 at Newark, and Nos. 67 to 71 inclusive at Lockport. This subject has had our earnest attention almost without interruption during the past year, and it is now believed that the problem can be solved surely and economically in a variety of ways, but after due consideration it has been decided to confine our studies to two of these methods and designs for each of these are well under way. While either of these designs is applicable for the improvement of any of the locks in question, it is now expected that the locks at Lockport will be the first ones to be improved on whichever of these plans it may seem advisable to adopt. It is expected that the contracts for this lock can be awarded during the coming summer in time to have the entire work ready for erection next fall, and it is also expected that the lock will be ready for operation by the opening of navigation in 1897.

Probably no other attempt at lock lengthening on the Erie Canal will be made until an opportunity can be had of studying the operations of this Lockport lock with a view of correcting such minor details as may require modification.

The problem of lock lengthening on the Oswego Canal will have attention during the progress of the surveys which are now under way, and no time will be lost in complying with the provisions of the law in this respect.

SHINNECOCK AND PECONIC CANAL.

Plans have been improved and contracts awarded for work connected with the Shinnecock and Peconic Canal, authorized by chapter 932 of the Laws of 1895, and consisting of a series or set of tide gates which are expected to help in raising the surface of Shinnecock Bay to its former height and maintaining it there, and also of dredging a channel about a quarter of a mile long, to connect the waters of Shinnecock Bay with the Atlantic Ocean. The first portion of this work is well under way, but before the results sought to be accomplished by its completion can be realized, it will be necessary to dredge out a portion of the canal that has been filled to a depth of about three feet, from the scouring effect of the water as it ebbs and flows through the contracted channel between the abutments of the Long Island Railroad Company's bridge. This bridge should be removed, and one of greater span substituted, and until this is done, serious trouble and expense will be encountered in maintaining this canal, but as questions relating to the responsibilities of the State and the railroad company in this matter are now before the Court of Claims for adjudication, no definite recommendations for the betterment of existing conditions can now be made. It would be useless to do further dredging in this canal till this bridge, which is now the source of all the trouble, is rebuilt as above suggested.

STATE LANDS.

The present constitution of the State, as well as former ones, provides that the State Engineer and Surveyor shall be a commissioner of the land office, and to him is referred by the commissioners applications for the purchase of lands, lands under water, special privileges on State lands, such as grants for mineral lands and other miscellaneous matters. These references require much time and attention, especially the applications for land under water, which are referred for examination of the maps and description to decide whether they are made in accordance with the rules of the commissioners of the Land Office, and if not so made to provide for the correction thereof.

It is often necessary to visit the premises to fix the lines of the proposed grants; to determine whether it might not prove to be an interference with navigation, or to fully satisfy himself that he can report to the commissioners that the grant can be properly made.

During the past year a larger percentage than usual of the applications have been contested, or objected to, which has involved much additional labor, as it often necessitated several hearings to the interested parties, and the adjudication of the contest and reporting to the land commissioners.

Forty-seven applications for land under water have been received, forty-five of which were for "beneficial enjoyment" and two for "commercial purposes." They were situated in sixteen counties of the State as follows: Westchester fourteen, Kings six, Richmond six, Erie six, Niagara two, Queens two, Otsego two, Suffolk one, Putnam one, Greene one, Rensselaer one, Orange one, Washington one, Ulster one, Rockland one, Columbia one.

The statutes prescribe that all the unappropriated land belonging to the State when sold must be by the State Engineer and Surveyer, under the directions of the commissioners of the Land Office. In the past fiscal year there has been received $10,256.25 for the sale of seventy-four parcels of land, situated in fifteen counties, as shown as follows: Richmond twenty-four parcels, Kings twenty-three, Niagara five, Chautauqua six, Westchester two, Rensselaer one, Albany one, Rockland three, Clinton one, Onondaga one, Oswego one, Cattaraugus one, Broome two, Tompkins two, Allegany one. There has been paid to the State Treasurer on account of fees received during the year the sum of sixty-six dollars.

Through the year numerous inquiries are made of the State Engineer and Surveyor which often require much time and study to answer understandingly and correctly; questions as to the proper locations of bulkheads and pier lines of the State, county, town and lot lines, of questions relating to field notes and maps of surveys that were made during colonial and early State times.

Numerous letters are received from surveyors asking for instructions or mode of procedure in their surveys. There is also a large amount of general correspondence relative to land matters and requests for copies of maps and notes of surveys and records of State lands and sales thereof.

SURVEYS FOR STATE INSTITUTIONS.

The officers of the various commissions, and those in charge of hospitals, asylums, prisons and other State institutions frequently have need of the services of engineers in connection with improvements either contemplated or already authorized at their several localities, and naturally this Department is usually called upon to do such work.

In many instances we have complied with such requests, and would gladly comply with all of them were it not for the fact that no funds are strictly available for such work. There can be no doubt of the advisability, from a business standpoint, of concentrating all such work under the supervision of this Department, and I urge that a suitable appropriation be made to cover such work.

COURT OF CLAIMS SURVEYS.

The course above outlined has for many years been followed in connection with all the surveys, maps, plans, etc., required by the Attorney-General to protect the State against all claims that may be brought for damages arising from the prosecution or maintenance of the varied public works by the State, and the results show that the plan is correct, intelligent and economical.

During the past year sixty-seven of these surveys have been made, together with the accompanying maps, plans, profiles and photographs, and these have materially aided in defending the State against no less than thirty-one claims, aggregating a total of $43,738.24, which have been settled or compromised for $9,197.

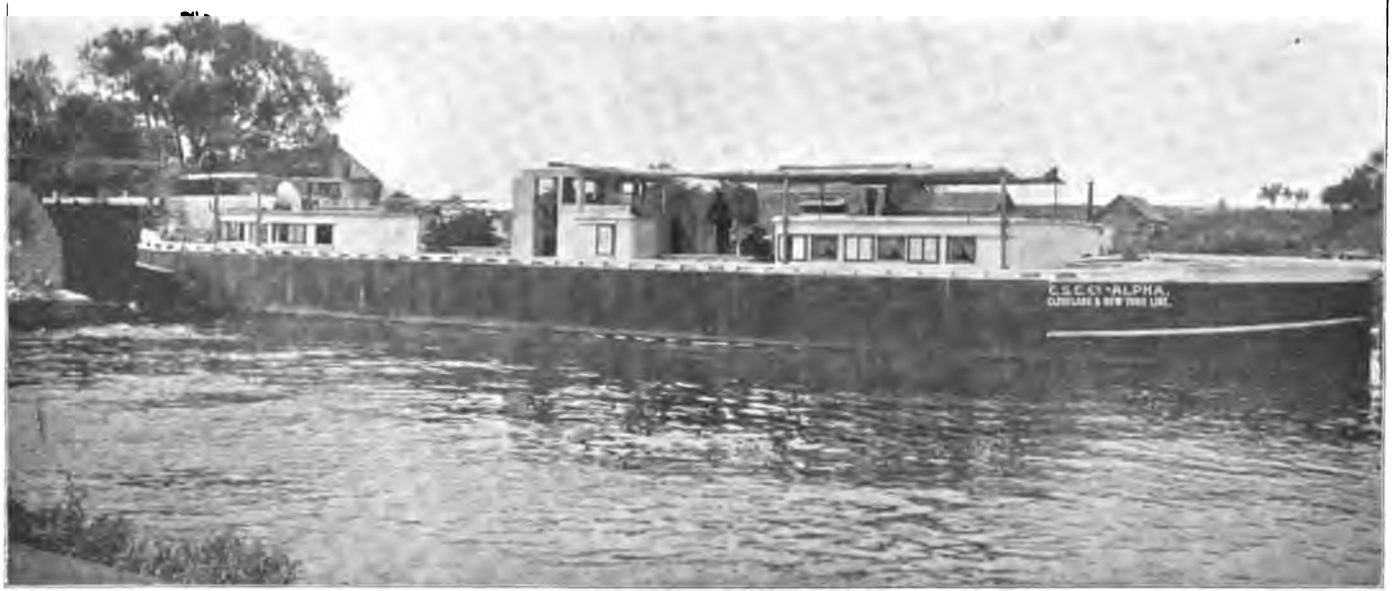
STEEL CANAL BOATS.

The past year saw an innovation in the manner of construction in canal boats.

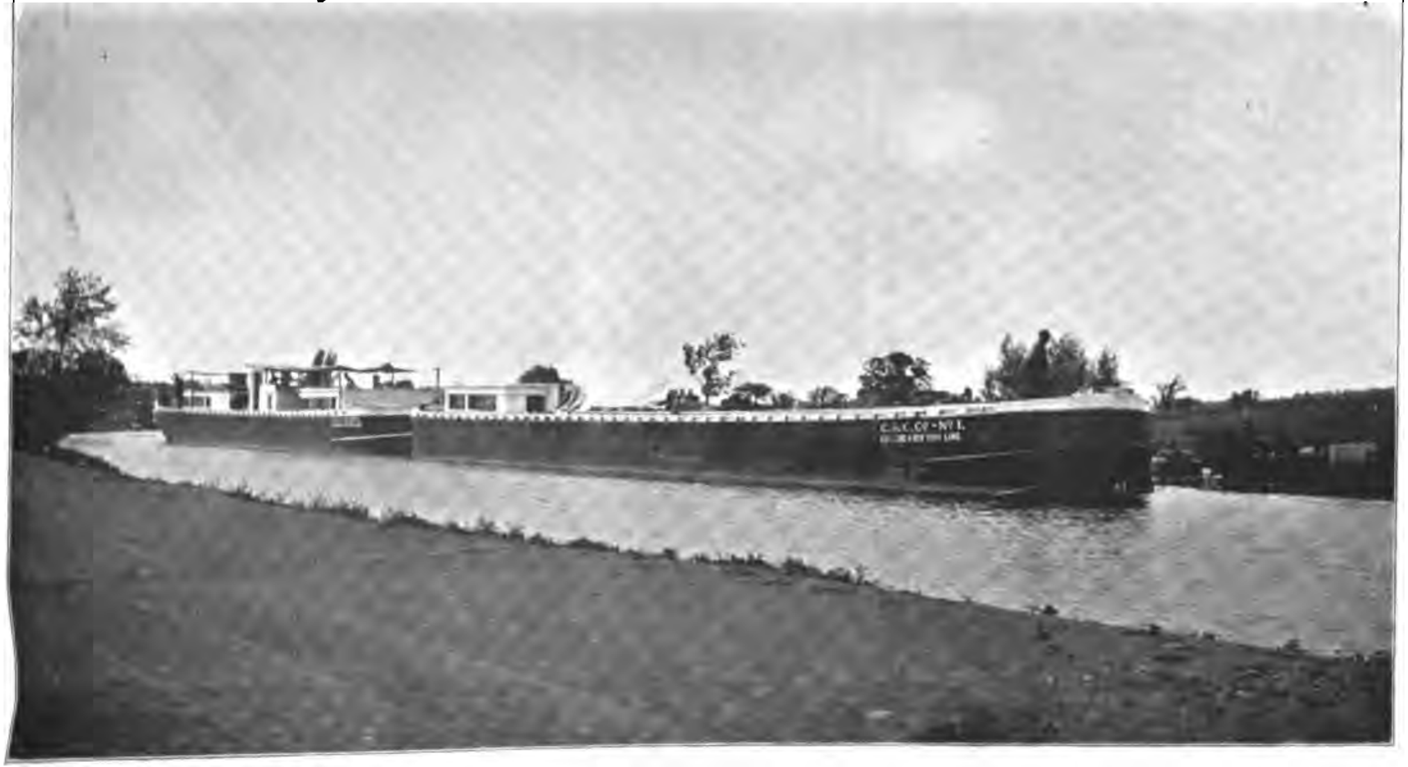
The Cleveland Steel Canal Boat Company, of Cleveland, Ohio, sent out, early in August, a fleet of steel canal boats, consisting of one steamer and five consorts, thus establishing a through line of transportation between Cleveland and New York, which was made possible and profitable for the reason that the insurance companies will insure these steel boats on the lakes, a risk never undertaken on the wooden boats now navigating the canal, and there is no reason why freight should not be carried on to Duluth from New York without breaking bulk, in these same boats. Their seaworthiness was well tested on two trips. Returning from the first trip to New York, they encountered the fierce storms on Lake Erie in October, and for twenty-three miles rode the gale in exclusive charge of the "Alpha," the name of the propeller, the tug running out of coal on this occasion. The return trip they were loaded with sugar shipped to Cleveland, Indianapolis, and St. Louis, and the damage to the cargo was practically naught, so little indeed as to make no claim whatever for insurance. On the initial down trip they were loaded in Cleveland with street-car rails for the Broadway Traction Railway in New York, and the Staten Island Traction Company. The second trip was commenced on October 10, and again they encountered northeast gales and rode them successfully. On this trip they were loaded with rails for Staten Island and export flour for Ireland, the first that has gone abroad from Cleveland via New York for years, the old route being via either Montreal, Philadelphia or Baltimore. Although difficulties were experienced on these trips, caused by new machinery, etc., the company felt encouraged enough by the success of the original fleet to place an order for three additional fleets, which will be ready for navigation in 1896.

The following is a general description of the original fleet:

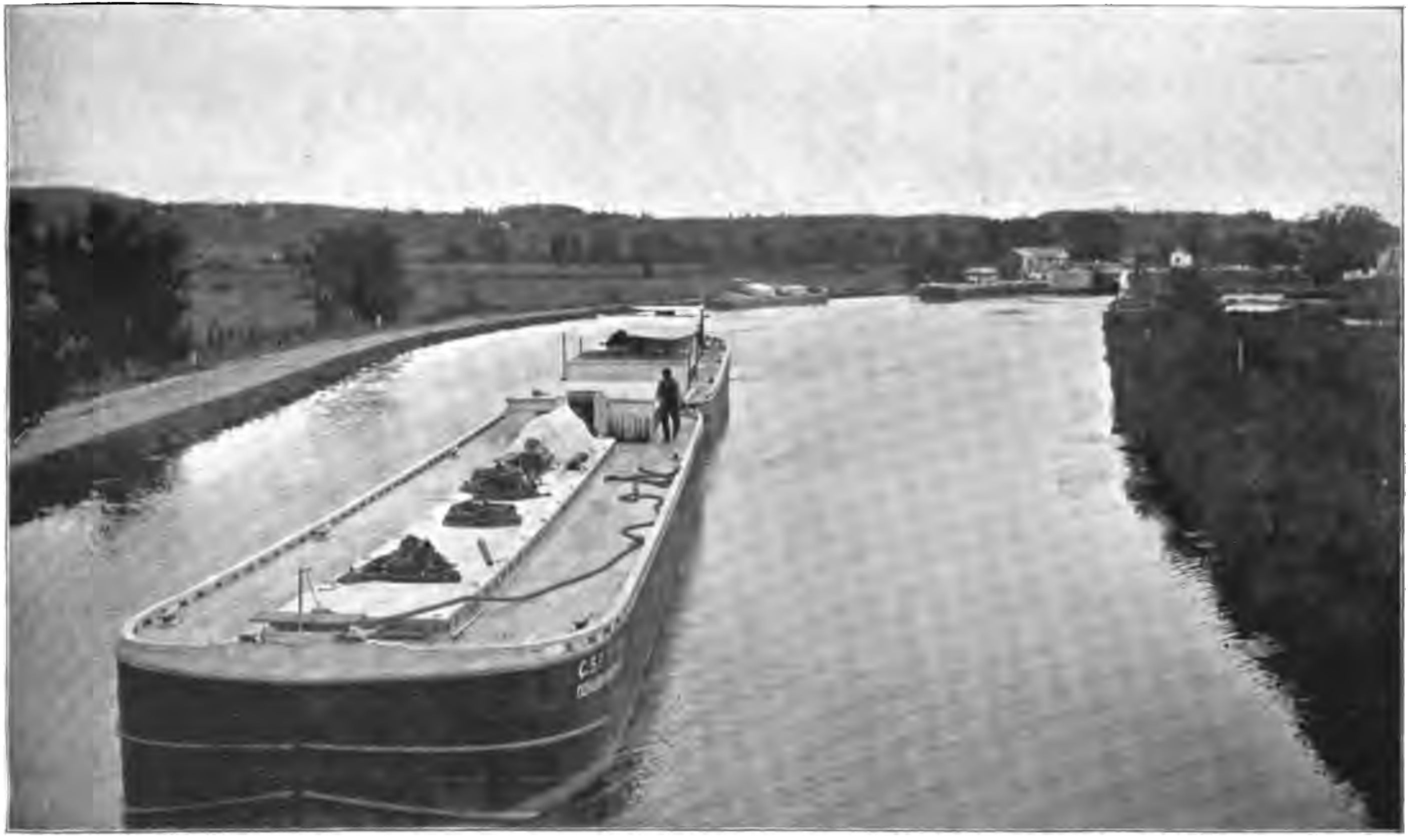
The boats are 98 feet over all in length, 17 feet 11 inches wide on top, 17 feet 4 inches wide at the bilge, and have a depth of 10 feet. They are constructed of three-eighths inch open hearth steel, the metal showing an analysis .02 of sulphur and .02 of phosphorus, and is mild and capable of bending very considerably before breaking. Floor timbers are on 22 inch centers. The bilges of the boats are reinforced by an extra ¼ inch plate of steel. Light, they draw 18 inches. The capacity of the consorts on 6 feet draught is 235 net tons; of the propeller 130 net tons. The boats, with the exception of the railing and the roofs of cabins, are entirely of steel. The propeller "Alpha" has a fine fore-and-aft compound engine of 120 horse-power, and turns a 5 foot 4 inch wheel 160 revolutions to the minute, the tremor



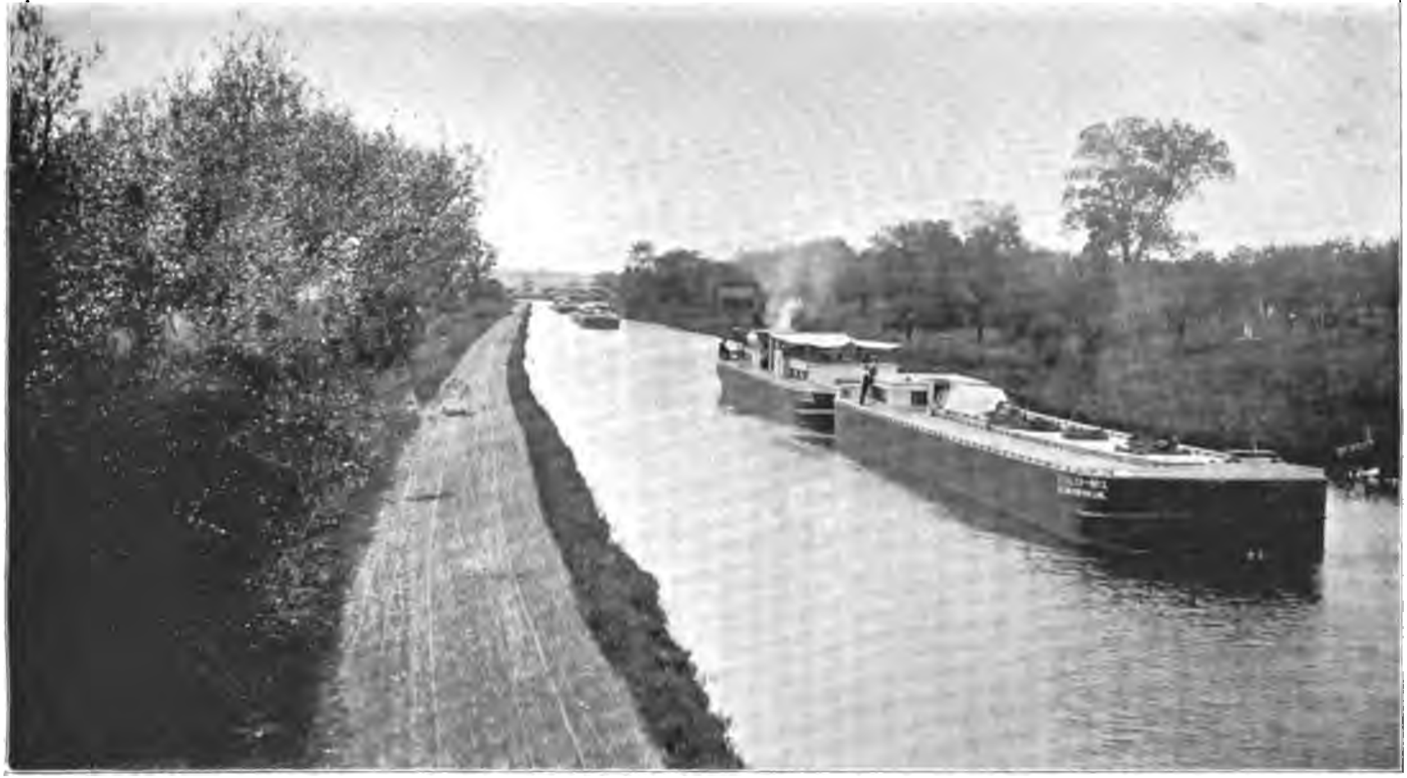
CLEVELAND STEEL CANAL BOAT STEAMER "ALPHA."



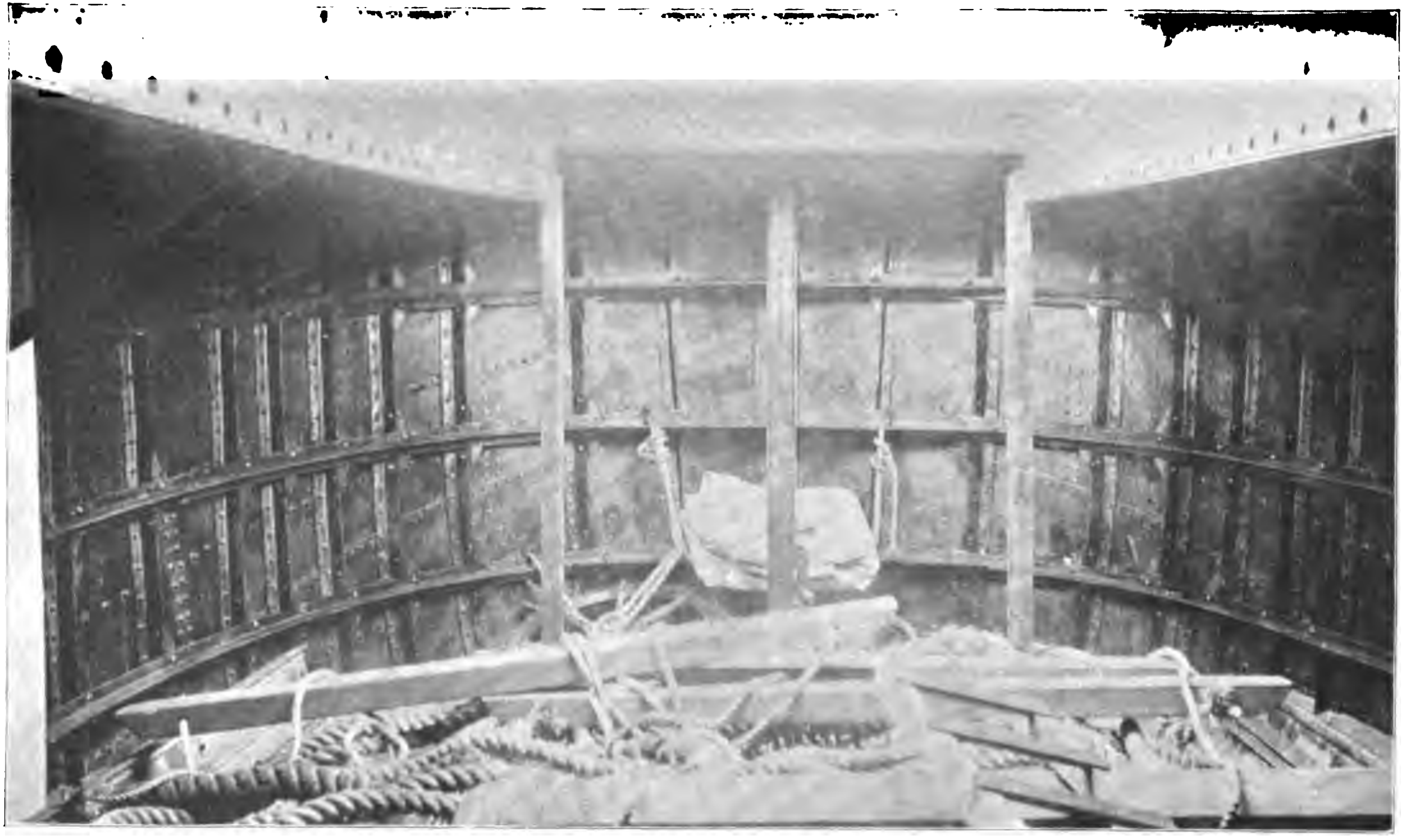
STEEL CANAL BOATS. STEAMER AND LEADING BARGE.



Steel Canal Boats. Middle Group of Barges.



CLEVELAND STEEL CANAL BOATS. THE WHOLE FLEET.



STEEL CANAL BOAT. INTERIOR, LOOKING TOWARD BOW.

on that account being almost imperceptible. The boiler is of the Scotch type.

Before starting on their second trip the fleet was thoroughly overhauled, and such changes made as had suggested themselves on the first trip.

The cost of this fleet will approximate $15,000 for the propeller and $6,000 for each consort. The best time made by the boats was thirteen days from New York to Cleveland, they being loaded to six feet draught. The best time from Cleveland to Buffalo was thirty hours in good weather, a loss of four hours of this time was due to a jam of boats at Tonawanda.

On account of the many changes that were made on the two trips in the machinery of the propeller no exact data is at hand at present of the cost of running each boat, but this will be arrived at in the coming year.

This year has mainly been spent in looking after defects in machinery and boats, in order to counteract them in the new fleets.

These new boats will be built on rather different lines. They will have a moulded depth of 12 feet instead of 10 feet, will have square bilges on the barges, double the power in the propeller and run in fleets of four instead of six. They will be provided with the same style of fore-and-aft compound engines, to be run at 200 revolutions per minute.

The company was dissatisfied with so many details in the original fleet, from the shape of the boat down to rudders, etc., that any figures for coal consumption would be meaningless, since they would prove mechanical defects which were expected, and will be obviated in the new fleet. But the main object, their entire ability to weather any storm on the lakes has been proven to the entire satisfaction of the company, and return cargoes of sugar have already been procured for the entire coming season.

Photographs showing the fleet on their first trip near Albany will furnish an idea of their general appearance.

TOPOGRAPHIC SURVEY OF THE STATE.

In connection with this matter your attention is called to that portion of this report relating to the "Topographic Survey of the Upper Hudson Valley." As will be observed from the terms of the agreement therein printed, this work was continued about on the lines laid down in a former agreement made in 1893 between this office and the United States Geological Survey.

The policy of having such topographic surveys made in this way has received the hearty welcome and indorsement of the last three State Engineers as well as of myself in my last annual report, but only after a careful and serious study of the best way to procure to the people of the State such an accurate and careful map as its wealth and the importance of its engineering undertakings demand.

It is my earnest hope that you will recognize the wisdom and economy of prosecuting this work through co-operation between the State and general government. The result has been the total expenditure by the latter of a sum equal to that devoted to such purposes by the State; in other words, of the reduction by half of the cost of this work to the State, while it was undoubtedly inaugurated more promptly and carried on more expeditiously and economically by the General Government, which has at its command a large and well-organized corps of trained topographers, than would have been possible on short notice by State officials.

In this connection, I again wish to urge upon you the desirability of continuing the policy of State and national co-operation in the making of a general topographic survey of the State about on the lines laid down in chapter 287 of the Laws of 1893. This matter was most earnestly brought to your attention in the report of my predecessor, Mr. Martin Schenck, in his annual report for the fiscal year 1893, and again by me, in my comments on page 48, in my annual report for the year ending September, 1894. No better indorsement of the value of such work to the people at large as well as to the State can be possibly asked for than that which is contained in the earlier part of this communication, and in the accompanying maps, and the more detailed ones now being engraved by the Government. It is of the greatest importance that such topographic maps should be in existence prior to the inauguration of public or private engineering works, and had they been in existence at the time of the passage of this act (chapter 599, General Laws of 1895), the fulfillment of the report therein required would have been greatly expedited, and its cost materially reduced. Scores of cities and villages throughout the State are vitally interested at this time in problems of water supply and sewerage, and the maps resulting from this survey, unlike any others heretofore published, show much that is valuable and useful in this connection. For the preliminary reconnaissance connected with such undertakings they are invaluable, as they show not only the relative location of points in the surrounding country, but also show by contours the forms of the hills and valleys, the areas of watersheds, possible reservoirs and their capacities, sites for dams and many other points which otherwise cannot be discovered except at the loss of much time and money for individual surveys.

Numerous other maps have been published locating at least the principal roads throughout the State; but these maps not only locate all the roads, but by also showing contours, they enable us to choose the level from the hilly roads. This information will be found invaluable in connection with any of the comprehensive plans for road improvement that are now being so extensively agitated, and some of which must soon take tangible form.

Another reason why this work should progress is that similar surveys and maps are now being made of all the States of the Union, and New York should not be behind her sisters in this great and uniform work, especially since we now have no reliable map of our State.

In connection with the canal system, also, these maps are of the utmost importance, especially at this time, for the information they will afford of the State's water resources for the supply of the canals. Careful studies of this question are already under way, since it seems certain that the deepening of the Erie, Oswego and Champlain Canals, which is now authorized and under way, will require for those canals an increased water supply.

The watershed tributary to the Champlain Canal has nearly all been mapped, as well as the territory tributary to Lake Champlain, except a small portion about the headwaters of the Saranac River, and one sheet on Lake Champlain. The watershed tributary to the Erie and Oswego Canals covers an area of 15,250 square miles, of which 2,950 have already been mapped, leaving 12,300 yet unmapped.

The total cost of mapping this area is estimated as follows by Director C. D. Wolcott of the United States Geological Survey:

6,140 square miles at $6	$36,840
3,080 square miles at $10	30,800
3,080 square miles at $20	61,600
Total	$129,240

Primary triangulation is already in existence over 4,300 square miles of this area, and the mapping of that could be commenced at very short notice. Such triangulation for the remaining 8,000 square miles could be completed in one season, at the cost of $22,000, making a total cost of mapping these 12,300 square miles $151,240.

This is at a trifle higher rate than the $10 per square mile estimated as the average cost of the whole State, for the reason that it includes a large proportion of the most difficult and expensive region in the State, or about one-half the Adirondack or North Woods region. This cost will cover the mapping also of cleared and timbered areas, and permit of more careful surveys in ten-foot contours where necessary, of all possible reservoir sites, thus facilitating the work of determining the possible lines for feeders and reservoir sites, and in measuring the catchment areas of tributary streams.

As an agreement similar to those heretofore made could doubtless be perfected for this work, the cost to the State would be one-half the above sum, or, in round figures, $75,000.

Prior to the last field season (that of 1895) there was mapped in the State of New York, by the United States Geological Survey, 9,009 square miles, of which 5,750 were mapped in co-operation with the State. During the past season there were mapped 1,123 square miles, making the total area of the State mapped to date 10,123 square miles. The total cost of the map work done prior to 1895 was $105,300, or at the rate of $10.62 per square mile. The director of the geological survey claimed at the beginning of co-operation that this work would average $10 per square mile, and that if the State would continue making appropriation for its prosecution at the rate of $25,000 per annum, his bureau would make a like appropriation, and that ten years would see the completion of this great work. The rate of mapping and its cost, as shown in the past, bears out this estimate, and it therefore appears beyond doubt that on the basis of an annual appropriation of $25,000 by the State, to be met by a like sum from the Government, the entire work can be completed in less than eight years, as there now remain 38,000 square miles of the State unmapped, and the expenditure of an annual appropriation of $50,000 by the co-operating parties will map at least 5,000 square miles per annum.

As I have had occasion to state in a previous report on this subject, such a work can be conducted under the direct control of the State officials, but it is also equally certain that, lacking as we do the organization and the trained topographers who are at the service of the Government, it is improbable that the State could do this work itself at the cost at which it is done by the Government, namely, $10 per square mile; while the fact must not be lost sight of that the expenditure by the State would be double that which it has to make when co-operating with the United States Geological Survey, which meets half the expense of the work. Finally, the maps being made, the State would have to engrave and publish them, in order that the public may get the benefit of them, while none of this expense falls on the

State under the terms of co-operation, as this engraving is done by the Geological Survey. I therefore again earnestly recommend that an appropriation of $25,000 be made for continuing of the co-operative topographical survey, under the joint direction of the State Engineer and Surveyor and the director of the United States Geological Survey, and to this effect suggest that a provision similar to chapter 287 of the Laws of 1893 be inserted as an item of the supply bill for 1896.

HUDSON RIVER STORAGE—CHAPTER 599, LAWS OF 1895.

Albany, N. Y., *January* 24, 1896.

We have the honor to transmit to the Legislature our report upon the survey of the watershed of the upper Hudson river, as provided by chapter 599 of the Laws of 1895.

After full consideration of the provisions of said law we determined that the subject was of such great importance that the report conveying the results of the examination and survey that might be made would be of the most value if made under the direction of an engineer specially qualified by experience in such matters. We accordingly directed Division Engineer DeWitt C. Smith, of the eastern division, to detail for this work George W. Rafter, assistant engineer in this Department, who had recently completed a report to the State Engineer on the Mount Morris storage reservoir.

It soon became apparent that the appropriation of $8,000 would permit of only a cursory examination of much of the territory available for storage of water, and we determined to embrace within the examination as much of the area of the watershed as possible, and confine detailed surveys to such portions as the means permitted.

We have been aided in a marked degree by the fact that under the joint topographical survey in progress between the United States Geological Survey and the State Engineer, we were enabled to obtain $4,000 from the United States Government, on the same terms on which the joint survey has heretofore been carried on, and by this means a considerable area has been surveyed and mapped and twenty-feet contours determined.

The final determination by the people that the canals shall be improved, have made this survey so far as it has progressed, of especial value, but it reveals the fact with singular clearness that to avail ourselves of the wonderful possibilities of this watershed, additional surveys and researches must be made with respect to particular sites for storage lakes and the dams creating them, and we urge an appropriation of at least $20,000 for the purpose of continuing the surveys required by said chapter 599 of the Laws of 1895.

(Signed) CAMPBELL W. ADAMS,
State Engineer and Surveyor.

(Signed) GEORGE W. ALDRIDGE,
Superintendent of Public Works.

TOPOGRAPHIC SURVEY OF THE UPPER HUDSON RIVER VALLEY.

Chapter 599 of the General Laws of 1895 provides, in part, that the "State Engineer and Surveyor shall, as soon as practicable, cause a survey to be made of the upper Hudson river valley, with a view to determining what lakes and streams may be improved or waters thereof stored or diverted, in order to provide for an enlargement of the Champlain canal; for restoring to the water-power of the Hudson river at or below Glens Falls the water diverted therefrom for canal purposes; and for improving the navigation of the upper Hudson river.

For the carrying out of the above purposes, the sum of $8,000 was appropriated.

Realizing that the first requisite for such an examination of the water resources of the Hudson river, as was above called for, could be best made through the agency of a careful topographic survey of the entire drainage basin of the Hudson river above Glens Falls, I cast about for the most expeditious and economical means of procuring such a survey. It became evident to me at once that the area to be examined was so great, including as it does, 2,820 square miles of the most rugged and inaccessible portion of the Adirondack region, that such a sum as had been appropriated, would scarcely make a beginning in this work. At the same time, it was evidently futile to attempt any intelligent and general discussion of the task allotted in the above act without the possession of a complete knowledge of the topography of the region under consideration. Recalling in this juncture that the United States Geological Survey had been cooperating with the State in the making of topographic maps during the years 1892 and 1893, it occurred to me that perhaps the director of the bureau would aid in making such a survey as was required, restricting it to the territory designated in the act. Accordingly, negotiations were opened with him to this end, which resulted in the drawing up of the following agreement:

AGREEMENT BETWEEN THE STATE ENGINEER AND SURVEYOR, THE SUPERINTENDENT OF PUBLIC WORKS OF THE STATE OF NEW YORK AND THE DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY, FOR THE SURVEY OF THE UPPER HUDSON RIVER VALLEY, AS PROVIDED IN CHAPTER 599 OF THE GENERAL LAWS OF 1895.

1. The preparation of the map shall be placed under the supervision of the director of the United States Geological Survey, who shall determine the method of survey and the map construction.

2. The survey shall be executed in a manner sufficiently elaborate to prepare a map upon a scale of 1 : 62,500, exhibiting the hydrography, hysography and public culture, and including all town and county boundary lines as established and marked by the State Engineer at the time of its completion in a form similar to the atlas sheets of the United States Geological Survey already completed in the State. The preliminary field maps shall be on

such a scale as the director of the United States Geological Survey may select as to secure accuracy in the construction of the final map.

3. The hysography shall be shown by contour lines with vertical intervals of twenty feet.

4. The heights of important points shall be determined and furnished to the State Engineer.

5. The Geological Survey shall pay the salaries of the persons employed therein, while the traveling, sustenance and field expenses shall be paid by the State in such a way as to equalize all expenses, provided that the total cost to the State of New York of the field and office work shall not be more than four thousand dollars, and provided that the United States Geological Survey shall expend an equal amount.

6. During the progress of the work, free access to the field sheets and records of the topographers and draughtsmen shall be afforded the State Engineer and his assistants for examination and criticism, and should the State Engineer of New York deem that the work is not being executed in a satisfactory manner, then the State Engineer may, on formal notice, terminate this agreement.

9. When the work is completed, the State Engineer shall be furnished by the United States Geological Survey with photographic copies of the manuscript maps.

(Signed) CHAS. D. WALCOTT,
Director United States Geological Survey.
(Signed) CAMPBELL W. ADAMS,
State Engineer and Surveyor.
(Signed) GEO. W. ALDRIDGE,
Superintendent of Public Works.

By the above agreement, I was enabled to procure the services of a trained corps of surveyors in the execution of this work, and to obtain for its prosecution double the amount of money which could otherwise have been allotted to it. In consequence thereof, I was enabled to devote half of the appropriation, or $4,000, to the more detailed engineering examinations which are reported on elsewhere, as under the direction of Mr. Geo. W. Rafter, while a sum equal to the total of the whole appropriation, or $8,000, was devoted to the topographic or reconnoissance examination.

I was informed by the director of the Geological Survey that much more careful work would be done in this particular region than had ever been performed by that bureau, in so far that special care would be taken in the survey of all possible reservoir sites, chiefly by running spirit level lines through such level valleys as reservoir sites may be found in.

From the report of the Hon. C. D. Walcott, director of the United States Geological Survey, which is appended hereto, it will be observed that 707 square miles were surveyed within the Hudson drainage basin, at a total cost of $5,776 for the field work only, and, including office work, incidental to the draughting of the maps, $7,336, or at an average cost of $10.38 per square mile. Of this sum the State expended $3,524, while the United States Geological Survey expended $3,812. In addition, and in order to fill out atlas sheets on the same general plan as that on which the United States Geological Survey is publishing its topographic maps, that organization surveyed in 1895, at its own expense, 416 square miles at a total cost of $3,398, making its own total expenditure during the year $7,210. This area is outside the drainage basin of the Hudson, but immediately contiguous to it, and its survey resulted in the completion of five additional atlas sheets, as shown in the accompanying progress map of topographic surveys, and in all of 1,123 square miles within the borders of the State.

Prior to 1895 there were surveyed by the United States Geological Survey in co-operation with the State, 130 square miles within the Hudson drainage basin. This work was published on the "Elizabethtown" and "Mt. Marcy" atlas sheets, and as a result there have been surveyed in all to date, 837 square miles of the Hudson drainage basin, leaving 1,983 square miles yet unmapped.

I desire especially to call your attention to the accompanying maps and to the following resume of the results accomplished by the topographic survey, as they show clearly and effectively the value and uses of such surveys in developing projects similar to that with which I have been intrusted.

The topographers have not only mapped for publication at the scale agreed upon, one mile to the inch and twenty-foot contours, the 1,123 square miles surveyed by them, but they have also furnished this office with photographs of these maps reduced to the scale of two miles to one inch, for use in compiling the general map of the Hudson river drainage basin, which is published in connection with Mr. Rafter's report. Moreover, they have furnished 215 bench marks, giving the elevation by spirit level, referred to mean sea level, of as many points scattered widely throughout the region surveyed. Above all, they have furnished a preliminary statement of the location, area, approximate capacity and dimensions of dams, of sixteen possible reservoir sites, having a total capacity of 9,225,000,000 cubic feet; while the general topographic map the areas of catchment basins which supply these reservoir sites with water can be readily measured It will thus be seen that this topographic survey has furnished a more complete, expeditious and economical preliminary survey of the water resources of this region than could have been obtained by any other method.

In the course of the mapping of the 1,123 square miles surveyed during the past year in the State of New York, the topographers located accurately by triangulation 4,050 points, such as the summits of hills, churches, houses, etc. They determined with precision the elevation above sea level of 4,250 points, either by spirit level or trigonometric methods; and with less accuracy, but well within the contour interval employed on the map, the elevation of 15,970 points. In addition, instrumental traverses for the control of the topographic sheets were made of 2,130 miles of roads and trails, while 390 miles of the shore lines of lakes were surveyed by triangulation or stadia.

From the above it will be observed that there were located instrumentally 3.5 positions per square mile or per square inch of map, for the horizontal control of the topographic maps; and there were determined for the vertical control of the map the elevations of 3.7 points per square mile, or per square inch of map surface.

Especially worthy of note is the fact that by July 19, or only seven days after July 12, the date of signing the agreement between the director of the United States Geological Survey, the Superintendent of Public Works and myself, the Geological Survey had placed in the field two fully equipped parties, while three others were added but shortly afterwards. All the surveying was done during the four months of July to October, inclusive, while reports and working maps were in my hands early in December.

In view of the great inaccessibility and the density of the timber covering of the region surveyed, and especially in view of the additional labors entailed in running level lines and making special examinations of possible reservoir sites, the director of the geological survey estimated that the total cost of this work would be about $15 per square mile, or its cost to the State $7.50 per square mile, a truly insignificant sum in view of the results achieved. As will be observed by the preceding statement of cost, the expense of this work was kept at $10.38, including office work and draughting, or well within these figures, thus showing again, as in the past, the ability of the United States Geological Survey to perform such work within their estimates; an enviable record in engineering work, and one which that organization has maintained during the four years which it has been cooperating with this office.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY.

Washington, D. C., *December* 6, 1895.

HON. C. W. ADAMS, *State Engineer and Surveyor, Albany, N. Y.:*

Sir.—I have the honor to make herewith a preliminary statement of the work done under the agreement signed on July 12, 1895, by the Superintendent of Public Works and the State Engineer and Surveyor of New York, and the director of the United States Geological Survey

By the terms of that agreement $4,000 was allotted by you for expenditure in making the co-operative topographic survey therein arranged for. Of this sum but $3,524.13 was expended during the field season which has just closed. The remaining $475.87 will, I presume, be available for field work next season. In the prosecution of the same work, namely, the survey of the Hudson river drainage basin, this survey has expended during the past season $2,252 on field work and $1,560 in the office work of draughting the final maps, making a total expenditure within this area of $3,812.

The result of this work has been the making of an accurate topographic map on the scale of 1 :62,500, and with a contour interval of twenty feet, of 707 square miles. The total cost for field work only was $5,776, or at the rate of $8.17 per square mile. The rate of cost including office work was $10.38 per square mile.

Moreover, this organization has surveyed 416 square miles contiguous to the Hudson drainage basin in order to fill out atlas sheets on the general plan of the topographic map of the State, and the expense involved in this work has been $3,398, making the total expenditure on the part of the United States Geological Survey $7,210, of which $5.650 was for field work, and the remainder for office work.

In addition, there were surveyed by this organization in 1893, 130 square miles within the Hudson drainage basin, making a total of 837 square miles surveyed to date in that basin.

Immediately upon the signing of the agreement under which this work was prosecuted Mr. J. H. Jennings, topographer of this survey, with two assistants, was ordered to commence work in the neighborhood of North Creek, and Mr. Frank Sutton, topographer, with one assistant, was ordered to commence work in the neighborhood of Paradox Lake. Both parties were at work prior to the 20th of July. Mr. E. B. Clark, topographer, commenced work in the neighborhood of Chestertown in August. In September Mr. W. M. Beaman, topographer, commenced work near-

Horicon, and at the end of the same month, Mr. R. D. Cummin, topographer, Mr. James McCormick, assistant topographer, and two assistants, commenced work in the neighborhood of Glens Falls. Field work for all of these parties was concluded early in November, and photographs of the field sheets reduced to the scale of two miles to one inch, and also on the scale of 1 :62,500, have already been forwarded you. I am,

Yours with respect,

CHAS. D. WALCOTT,

Director.

SPIRIT LEVEL ELEVATIONS IN THE UPPER HUDSON VALLEY.

These elevations do not include all those determined in the work, and others will be sent you later when tabulated. In addition there have been determined many hundreds of elevations by vertical angulation, and these are correct within two or three feet. They have been used in locating the position of contours on the topographic sheets.

Some of these elevations are given to even feet only, others to tenths and hundredths of feet. This leveling was done by us not with a view to obtaining precise elevations of points above sea level, but only to get these elevations with a sufficient degree of accuracy to insure their being well within a contour interval. Also, they were determined with sufficient accuracy to give correctly relative differences of elevation over various portions of this work; but these lines have not always been so connected, one with the other, as to enable us to reduce them all to sea-level much within one even foot. Thus, a number of checks on the elevation of the dam at the outlet of Schroon lake, brought both from the railroad and from Lake George, agree among themselves, but differ from elevations brought from Crown Point to the head of Schroon lake by one foot. This discrepancy is bunched, in the notes, in Schroon lake, a difference of one foot being allowed to appear between its upper and lower ends.

Elevations are given to even feet where there is no permanent bench mark, as the ground surface at the summit of a road. They are given to tenths of a foot where the bench mark is of a more permanent character, as the wooden floor of a bridge or floor of a house. They are given to hundredths of a foot where the character of the bench mark is more permanent still, as a well-defined rock, or the rail of a railroad. It has not seemed necessary to take the time just now to reduce all of these elevations to hundredths of feet.

Line from Crown Point to Schroon Lake, via Crown Point Center, Hogback road to Old Furnace, Forest House and Paradox. Spirit level elevations.

Town of Crown Point.

Crown Point railroad station, top of rail	126.
Crown Point post office, platform of	215.49
Crown Point post office, surface of red wooden bridge one mile west of	174.37
Pond's store (platform at corner), 150 feet beyond red bridge	184.12
Crown Point Center, porch of Center House	292.38
Surface of red bridge one-half mile beyond saw-mill	492.26
Top of stump at road junction one-eighth mile east of watering trough	657.23
Large rock at road corner 200 feet west of watering trough	670.72
Sherman Corners	960.
Hogback road, summit of, doorsill of house	1,088.
Road corner, one mile west of last	1,006.8
Red schoolhouse, road corner by	1,033.9
Yellow house, lowest stone step of, on right, one-half mile west of red schoolhouse	1,109.7
Hogback road, south end of bridge at junction with Black Brook road	1,093.92
Old Furnace, second railroad crossing east of	1,175.91

Old Furnace, northwest corner of bridge at south three-corners	1,140.73
Dudley Pond, water level	940.
Dudley Pond, bent tree on north side of road just north of old Dudley dam	952.18
Forest House, northeast corner of bridge over Paradox Brook, one and one-fourth miles northeast of (just south of old Dudley dam)	934.08
Forest House, Paradox Brook, one mile northeast of, northwest corner of floor of bridge	926.27
Forest House, Kumph Pond, one-third mile northeast of, northwest corner of floor of bridge over outlet	933.16
Forest House, northwest corner of porch	952.96
Paradox, doorsill of red schoolhouse (Letson's), two miles north of	925.02

Town of Schroon.

Paradox, northwest corner of floor of bridge over Paradox Brook at Letson's saw-mill, one and one-fourth miles north of	874.69
Paradox, west end of log bridge at road corner, one-third mile north of	888.40
Paradox, northeast corner of stone step in front of schoolhouse	875.14
Paradox lake, water surface	820.
Severance, large rock in middle of triangle at three-corners, near schoolhouse	876.25
Severance, large rock north side of road at three-corners near schoolhouse (Colvin, B. M.)	875.23
Severance northeast corner floor of bridge over creek from Paradox Lake	833.64
Schroon Lake, watering trough edge two miles north of	870.99
Schroon Lake, Arlington Hotel, sidewalk at gate in front of	891.

Schroon Lake, Ondawa Hotel, veranda of	853.32
Schroon Lake, Rogers' Brook, southwest corner of bridge over	841.47

Line from Old Furnace to Hammondville. Spirit level elevations.

Town of Crown Point.

Hammondville, Congregational Church, foundation rock, southeast corner of	1,405.56
Hammondville, red pump, southeast corner of platform, on road to Crown Point, one-fourth mile northeast of railroad station	1,362.41
Hammondville, railroad station, top of rail in front of	1,326.32

Line from Old Furnace to Old Pond. Spirit level elevations.

Town of Crown Point.

Round Pond, center of bridge on Black Brook road, one mile south of	961.37
Round Pond, water level	987.

Line from Paradox, N. Y., to Crane Pond, Pyramid and Paragon Lakes. Spirit level elevations.

Town of Schroon.

Paradox Lake, water level	972.
Pyramid Lake, crest of dam at outlet	971.90

Town of Ticonderoga

Paragon Lake, middle of bridge, one-third mile west of, on road to Pyramid Lake	1,001.2
Paragon Lake, water level	951.

Town of Schroon.

Crane Pond, water surface	1,091.
Crane Pond, west end of log at end of trail from Pyramid Lake	1,092.18

Level line from Schroon River Post office to Boreas River. All spirit level elevations.

Town of North Hudson.

Schroon River post office, B. M., bridge at corner one-third mile south of	873.7
Schroon River post office, B. M., surface of bridge over Schroon River, one-half mile south of	858.
Schroon River post office, B. M., surface of bridge over Schroon River, two miles southwest of	975.5
Blue Ridge, B. M., top of large rock by corner of fence by new white house, one-fourth mile east of	1,110.8
Blue Ridge, B. M., lowest step of post office	1,140.5
Blue Ridge, corner of piazza John May's hotel	1,219.9

Schroon River to Boreas River.

Blue Ridge, B. M., surface of iron bridge, one-fourth mile west of	1,154.8
Blue Ridge, B. M., center of middle bridge over "The Branch," two and three-fourths miles west of post office	1,236.5
Boreas River, B. M., surface of wooden bridge over "Gulf Brook," four and one-half miles east of post office	1,583.6
Boreas River, edge of watering barrel, four miles east of	1,745.7
Boreas River, summit two and three-fourths miles east of	2,027.1
Boreas River, B. M., lowest step of Sand Point Hotel, two and one-half miles east of post office	1,976.8
Boreas River, B. M., at well curb at summit of road, one and three-eighths miles east of post office	1,956.1
Boreas River, B. M., surface of bridge at post office	1,738.

Level line starting at watering-tub, two miles north of Schroon Lake, to Hammond Pond, via Schroon Falls, Schroon River and North Hudson. Spirit level elevations.

Town of Schroon.

Schroon Lake post office, edge of watering-tub, two miles north of	871.

Schroon Lake post office, base of signpost, two and one-half miles north of	859.1
Schroon Falls, B. M., surface of bridge over Schroon River	830.4
Schroon Falls, B. M., top of rock by house on west side of road, one and one-half miles north of	937.2

Town of North Hudson.

Schroon Falls, pointed rock by house on right side of road, two miles north of	920.9
Schroon River post office, platform of schoolhouse, one mile south of	930.
Schroon River post office, floor of bridge, one-half mile south of	873.7
Schroon River post office, surface of bridge by Corson's Hotel	864.3
Schroon River post office, surface of bridge, one and one-half miles north of	871.3
North Hudson post office, B. M., surface of new bridge, one-third mile north of	915.3
North Hudson post office, doorsill of church, one-half mile north of	970.5
North Hudson post office, southwest corner of Pine Ridge Cottage	957.4
North Hudson post office, surface of bridge, one and one-half miles east from church	928.9
Black Brook road, surface of bridge over stream from Berry mill pond	943.8
Hammond Pond, water level	984.

From Brant Lake to Riverside, via Chestertown. All spirit level elevations.

Town of Horicon.

Brant Lake, surface of bridge at lower end	807.1
Horicon, lower step of store at corner	798.2

Horicon, road corner, three-fourths mile southwest of, base of telegraph pole	837.6
Starbuckville, bridge surface about ten feet from north end, east side	813.7
Starbuckville, north end of dam	808.4
Starbuckville, middle of dam	806.7
Starbuckville, south end of dam	808.9

Town of Chester.

Chestertown, lower step of house, edge of woods, one-half mile east of	877.6
Chestertown, eastern end of stone cross-walk in front of Chester House	854.4
Chestertown, cross roads, two miles west of middle of doorsill of schoolhouse	873.
Chestertown, top of dam, Loon Lake (dam even)	865.57
Riverside, B. M., rock in middle of road at white house one mile east of	905.16

Town of Johnsburg.

Riverside, top of rail opposite station	882.1

Schroon Lake to Thurman Pond. Spirit level elevations.

Town of Schroon.

Schroon Lake	807.
South Schroon, floor of bridge over mill pond, main road	853.3
South Schroon, mill pond by cider mill, crest of dam	879.4
Thurman Pond, water level	891.3

Loon Lake to Mountain Spring Lake, near Pottersville, N. Y. Spirit level elevations.

Town of Chester.

Loon Lake, top of dam	865.57
Loon Lake, corner of roads northeast of	881.2
Pottersville, on rock just south of corner of road one and one-fourth mile southwest of	930.5

Mountain Spring Lake, water level	900.4
Warner's Pond, water level	916.8

Schroon Lake to Aiden Lair, via Rogers and Oliver Pond, Homesteadville and Minerva. All spirit level elevations.

Town of Schroon.

Schroon Lake post office, road corner Catholic church	841.6
Schroon Lake post office, road one-fourth mile west of Catholic church	858.4
Schroon Lake post office, road corner one and one-half mile west of Catholic church	1,127.
Schroon Lake post office, B. M., surface of bridge, one and three-fourths mile west of	1,206.9
Horseshoe Pond, B. M., at red painted rock by three birches at road corner north of	1,351.3
Horseshoe Pond, water surface	1,287.6
Rogers' Pond, B. M., at lone stone (painted red), at boat landing	1,284.9
Rogers' Pond, water surface	1,284.
Little Rogers' Pond, upper stone step in front of red house by	1,288.6
Little Rogers' Pond, water surface	1,266.9
Little Rogers' Pond, road corner, one mile west of	1,312.8
Loch Miller post office (Hoffman), B. M., surface of bridge over Trout Brook, three-fourths mile east of	1,185.2
Loch Muller post office (Hoffman), B. M., at big rock by house, one-third mile east of	1,331.8
Loch Muller post office (Hoffman), B. M., stone by gate, front of house, one-fourth mile south of (just east of schoolhouse at corner)	1,389.1
Loch Muller post office (Hoffman), B. M., small rock (painted red), one-half mile west of schoolhouse, three-fourths mile southwest of	1,428.8
Muller Pond, B. M., stone by poplar at entrance to and one-eighth mile north of	1,486.2

Muller Pond, B. M., on boards across roads at corner, one-half mile east of	1,446.6
Muller Pond, water level	1,466.6
Bigsby's Pond, B. M., porch of Butler's house, one-fourth mile east of	1,530.6
Bigsby's Pond, water surface	1,562.2
Oliver Pond, water surface	1,486.3
Oliver Pond, B. M., surface of bridge at outlet	1,361.5

Town of Minerva.

Irishtown Hotel, road corner, one and one-third mile north of	1,181.2
Irishtown Hotel, bottom step of veranda of house, one and one-eighth mile north of	1,188.1
Irishtown, B. M., on stone, five feet east of road at corner	1,169.5
Olmstedville, B. M., middle of floor of iron bridge	1,143.3
Olmstedville, surface of iron bridge, three-fourths mile west of	1,151.5
Olmstedville, road corner, one mile west of	1,158.
Morris Corners, B. M., middle of step of (unpainted) house, northeast corner of roads	1,308.5
Baptist church, northwest corner of underpinning	1,388.
Kellogg's, B. M., middle of porch of	1,389.1
Kellogg's, B. M., stone platform, one-fourth mile west of	1,345.
Kellogg's, bottom of iron watering trough, one mile west of	1,442.9
Kellogg's, road corner, two miles northwest of (to Northwoods Club)	1,733.8
Kellogg's, two miles northwest of, B. M., north end of doorsill of old store, 500 feet north of road to Northwoods Club	1,733.8
Bullhead Pond, water surface	1,868.
Kellogg's, road summit, three miles west of	2,043.

Aiden Lair, B. M., doorsill of house on west side of road two miles south of	1,932.6
B. M., on large white stone in front of telegraph pole 200 feet from road to Long Pond	1,792.1
Balfour Pond, water surface	1,782.
Aiden Lair Hotel, northeast corner of, lower porch	1,644.6
Hewitt Pond, water level	1,692.
Aiden Lair, B. M., center of iron bridge over Boreas River, one and one-half miles west of	1,603.

Chestertown to Tripp Pond. Spirit level elevations.

Town of Chester.

Chestertown, cross-walk in front of Chester house	854.4
Chestertown, road corner, one-half mile south of	833.
Cunningham Pond, three-fourths mile south of Chestertown, water level	831.
Chestertown, road corner, three-fourths mile south of, leads to west	856.
Mead Pond, one-half mile south of Chestertown	848.
Chestertown, road corner, two and one-fourth miles south of, leads to west	924.
Darrowsville, cross-roads	956.

Town of Johnsburg.

Tripp Pond, water level	958.

Cross-roads by schoolhouse two miles west of Chestertown (on road to Riverside) to Friends' Lake. Spirit level elevations.

Town of Chester.

Chestertown, middle of doorsill of schoolhouse at cross-roads, two miles west of	873.
Chestertown, first mill dam (one-half mile) south of cross-roads, two miles west of	878.5

Chestertown, road forks, near church, three-fourths mile south of crossroads, two miles west of	921.
Friends Lake, road forks, one-fourth mile north of dam at outlet	916.3
Friends' Lake, crest of dam at outlet	914.6

Rivertown to Johnsburg, Spirit level elevations.

Town of Johnsburg.

Riverside, top of rail opposite station	882.1
Riverside, top of large round rock, one and one-half mile south, on west side of road in front of white house, top of hill	1,034.2
Weavertown Hotel, road corner, two miles east	915.5
Weavertown Hotel, road corner, one and one-half mile east	945.4
Weavertown Hotel, floor of bridge over mill brook, one mile east	966.4
Weavertown Hotel, cross-roads near saw-mill, one and three fourths mile east	973.
Weavertown Hotel, bench mark top of watering-tub, one-half mile east	1,007.4
Weavertown, platform of store at corner	1,050.
Weavertown, east end of lower wooden step, upper hotel	1,067.1
Johnsburg, road corner, one-half mile east of	1,085.8
Johnsburg, platform of Noble's store, B. M	1,293.8

Road from Lamb Schoolhouse (on east side Schroon River, eight miles below South Horicon, and two and one-half miles above stone County house) to Brant Lake. East side of river south of Middleton bridge and west road above Middleton bridge. All spirit level elevations.

Town of Bolton.

Lamb Schoolhouse, first house north of, nail in north-east corner of well cover	747.33
Lamb Schoolhouse, first road corner, one mile north of	725.

Middleton bridge, highest point in road, one and one-half mile south of	817.
Middleton bridge, three-fourths mile south of doorsill of Hank Roberts' house	732.61
Middleton bridge, floor of south side over pier	719.
Middleton bridge, three-fourths mile north of, floor of bridge over brook	745.
Middleton bridge, road corner, one and three-fourths mile north of stone step at house	763.28

Town of Horicon.

South Horicon, west side of bridge over Schroon River	792.7
South Horicon, road corner at	789.
South Horicon, road corner, one-half mile north of	796.
Horicon, stepping-stone marked "S. Barton"	799.40
Horicon, sill of door of frame church	803.68
Brant Lake, cross mark in east stone abutment of dam at outlet	806.62
Brant Lake, surface bridge at lower end	807.1
Brant Lake, road corner near bridge at foot of lake and one mile northeast of Horicon	809.
Brant lake, water level	801.

Thurman Station (Adirondack Railroad) to Johnsburg, via Athol post office, High street, and Thurman post office. All spirit level elevations.

Town of Thurman.

Thurman Station, rail in front of	616.
Athol, floor middle of bridge, east of Bowen House	744.1
Athol, platform at Bowen	765.
Athol, middle of road opposite church	802.
Athol, first house west of corner, three-fourths mile west of church, road surface	998.
Athol, road corner, one and one-half mile west of church	1,154.

Athol, road corner, one and three-fourths mile west of	1,223.
Athol, porch of Smith's house, western of two houses near road corner, two miles west of	1,243.2
Smith's house, road corner east	1,237.5
High street, road corner, one and one-half mile south by west from summit of No. 9 Mountain north corner of grass in road triangle	1,286.
High street, floor of bridge, one-eighth mile northwest of	1,310.
No. 9 Mountain, stone slab in front of steps of first house (east side of road) south of the highest point in road, opposite mountain	1,563.66
Thurman post office, top step of yellow house east side of road, one and one-half mile southeast of; first house (three-eighths mile) south of Patterson Brook	1,437.96
Thurman, one mile southeast of, porch of J. King's house, west side of road, one-fifth mile northwest of Patterson Brook	1,315.6
Thurman, platform of Pasco's store and post office	1,315.
Thurman, platform in front of church	1,264.6
Thurman, road corner northwest of, near town line	1,286.

Town of Johnsburg.

Thurman, one and three-fourths mile northwest of, doorsill of red house, east side of road	1,274.83
Thurman, floor of bridge over large brook, two miles north of, one-fourth mile from schoolhouse	1,177.9
Thurman, road corner (to the Glen), two and one-fourth miles north of	1,178.
Thurman, road corner (leads to west), three miles northwest of, and three-fourths mile northwest of schoolhouse	1,311.
Johnsburg, three miles south of, doorsill of house west side of road, second house south of highest point in road	1,524.

Johnsburg, two miles south of, step of house east side of road, one-half mile southwest of road corner	1,370.77
Johnsburg, one and one-half mile southeast of, door-step of house at road corner	1,353.6
Johnsburg, road corner, one mile southeast of	1,355.
Johnsburg, three-fifths mile southeast of, underpinning of southwest corner of house, east side of road, near four large Lombardy poplars	1,300.73
Johnsburg, platform of hotel at cross-roads	1,293.7

Road from Warrensburg to Thurman Station (on Adirondack Railroad). Spirit level elevations.

Town of Warrensburg.

Warrensburg, porch of Adirondack House	745.4
Warrensburg, road just in front of carriage platform at Warren House	702.
Warrensburg, road just in front of carriage platform at Grand Army House	695.
Warrensburg, floor middle of Osborne bridge (by H. Herrick's store)	683.
Warrensburg, height of dam by large red building just beyond grocery store, and one-half mile below Osborne bridge	651.5
Warrensburg, road corner (road to Harrington Hill), three-fourths mile from Osborne bridge	649.
Osborne Bridge, floor of bridge over small stream one and one-fourth mile west of	645.6
Thurman Station, middle of road in front of school-house, three-fourths mile east of	621.

Town of Thurman.

Thurman Station, floor of bridge over Hudson River, under sign "Fine $10, etc.," near south end	621.9
Thurman Station, Adirondack Railroad, top of rail	616.

Line from station 118, Verplanck Colvin, at North River, New York, along Hudson River, to the mouth of Boreas River. Spirit level elevations.

Town of Minerva.

North River, B. M. of F. N. Sanders, also No. 118 of Verplanck Colvin	1,085.58
North River, B. M., marked E. in black paint on large rock, about one mile north of	1,110.64
North River, B. M., on doorsill of first house, one and one-half mile north of	1,101.28
Hudson and Boreas Rivers, confluence of; rock marked with bright red paint "B. M. U. S. G. S." at end of road on bank of Hudson River near old camp	1,165.49

Profile Map of an enlarged canal via the Oswego Route will be found in pocket inside front cover of book.

REPORT.

Hon. Campbell W. Adams, *State Engineer and Surveyor:*

Sir.— I have the honor of submitting herewith a report on the subject of an enlarged canal on the so-called Oswego route.

Respectfully yours,
ALBERT J. HIMES,
Resident Engineer, Eastern Division, New York State Canals.

Sir.— In accordance with instructions received from you on the 24th day of August, 1895, I have made an examination of the so-called " Oswego Route " for an enlarged canal and submit herewith a report exhibiting all information that has been obtained concerning it. The object of the examination has been to secure a profile and description of the route and to prepare an estimate upon the cost of constructing a canal along that route.

The work has been simply a hasty reconnoissance and nothing precise has been attempted. Elevations have been obtained mainly from established benches along the Erie canal, distances have been estimated from published tables of distances along the Erie canal and Oswego canal and the New York Central Railroad. and in some cases they have been determined by scale from the U. S. geological maps. A few stadia lines have been run to supply portions of the route otherwise unobtainable. All field work has been done with the stadia. The character of the estimate is, therefore, only preliminary and is valuable only to determine the advisability of a complete instrumental survey, should the necessities of canal improvement require such a radical change in our present system.

The great interest in enlarged canals manifested by the recent convention of the Deep Waterways Association, and by the citizens of New York State in the late election, has made it desirable to obtain better information about the cost of such a work as the one proposed than has been heretofore available. It is believed that this report will supply such information and enable a more intelligent opinion to be formed concerning the value of this route for an enlarged canal.

It is only just to say that no special fund was available for this work, and everything that has been accomplished was done at such odd moments as could be snatched from the routine work of this division. This fact will sufficiently explain the absence of all detailed estimates of individual structures, which would require much time and study.

The recent marvelous growth in the traffic upon the great lakes and the contemporaneous decline in the business done upon the Erie canal, have caused far-sighted and patriotic men to become apprehensive that the great commercial route which has made New York the Empire State, and New York city the greatest commercial center on the continent, might, in time, become completely obliterated and the commercial supremacy of the State itself endangered. With characteristic sagacity and enterprise, these men have, for several years, been seeking some means by which to avert the impending calamity and to place the prosperity of the State of New York upon a foundation as enduring as that of our national government. The only means yet suggested for securing this most desirable condition is the construction of a waterway through the State, upon which freights may be carried at a rate so low that no other route could compete with it. It is generally conceded that freight can be handled more cheaply in boats than in cars, but the particular method of transportation by water and the proper dimensions of the proposed waterway are open questions concerning which there is a wide difference of opinion among the men most competent to judge. These questions have not been considered in this report, the object of which has been simply to discover the advantages and disadvantages existing upon the "Oswego route."

The opinion of experts in regard to the merits of the various routes and modes of construction, are as varied as they are in regard to the proper dimensions of an enlarged canal and the mode of transportation. It may, therefore, be stated that the selection of the "Oswego route," for investigation was determined chiefly because of its proximity to the work of this division and the comparative convenience for doing the work.

In the beginning we are confronted with the following popular beliefs concerning this route which have been created by statements made by some of our most eminent engineers.

First.— The water supply on the summit level is wholly inadequate.

Second.— To secure a proper supply of water would require the construction of a costly feeder reaching from Lake Erie to Rome.

Third.— The construction of a canal having a depth of water of twenty feet and extending from Buffalo to Albany, would cost $200,000,000 and the land damages would be fabulous.

Applying this to the "Oswego route" we might infer the cost of construction to be $100,000,000, and the land damages to be semi-fabulous, or say a total of $200,000,000.

Fourth.— To create a system of slack water navigation in the Mohawk valley, as has been proposed by Hon. Elnathan Sweet, would cause endless damage to cities in time of flood, and require the elevation of the tracks of the West Shore and New York Central Railroads to higher ground.

These beliefs considered as obstacles are truly appalling, but we were somewhat skeptical as to their merits and therefore did not allow them to hinder the investigation.

The route, as selected, leaves the Hudson river at the West Troy side-cut of the Erie canal and follows the Mohawk river to Rome, where it enters Wood creek and passes into and across Oneida lake and down the Oswego river to Lake Ontario.

The United States geological maps were available from West Troy to Amsterdam, and from Utica to Brewerton; distances, profiles, and cross-sections were taken directly from these maps.

These data were supplemented by a series of stadia cross-section taken at intervals sufficiently close to insure a uniform slope of the river bed, between sections. Profiles were made with the stadia of parts of the route at Schenectady, Rome and Phoenix. At other places the published distances along the Erie canal were used. All levels are referred to canal datum, which is 0.0 at mean low-water in Albany and 3.64 feet above mean low-water at Governor's Island in New York harbor.

A map of the route, showing its approximate location, the position of all proposed locks and dams, and all highway and railroad crossings and also a profile showing the proposed cuttings, locks, dams, elevations and lengths of levels accompany the report. Cross-sections of the dam sites are also submitted, it being intended to exhibit all data collected in order that the estimates may be easily verified. In the absence of more exact data there is a chance for a wide difference of opinion about the cost of the various structures. It has been the intention however, to make all estimates exceedingly liberal in order to avoid the error of making the route appear unduly favorable by under-estimation.

GENERAL DESCRIPTION.

To a certain extent the proposed waterway follows the lines suggested by Hon. Elnathan Sweet in his celebrated paper published by the American Society of Civil Engineers, in 1884.

It is proposed to convert the Mohawk river into a series of level pools, by means of dams and to make the bottom width of the canal 100 feet, the depth twenty feet, and the size of the locks 450 feet by sixty feet. The depth of twenty feet has been adopted by the United States engineers as a standard in the improvement of lake channels, which is a very good reason for considering it as the desired depth in the enlarged waterway, although there are advocates for all depths between ten feet and twenty-six feet. It is, however, apparent that, for exhibiting the features of the route, a depth of twenty feet is as good as any other.

The maximum proposed lift of a common lock is twenty-seven feet. Locks of greater lift were used in the Lehigh Valley canal and one lock having a lift of fifty-three feet was proposed on the Nicaragua canal by Mr. Menocal.

The new "Soo" lock has a lift of about nineteen feet. It does not appear, therefore, that a lift of twenty-seven feet would be at all impracticable.

The United States government engineers have established harbor lines at Albany, Troy and Oswego. These lines include the Hudson river to the State dam at Troy, and the Oswego river from its mouth to the State dam known as the Oswego or Horseshoe dam. In the Hudson, for several miles below West Troy, there is now a depth of water not greater than twelve feet, and just below the Oswego dam the bed of the river is a trifle higher than low water in the lake.

The distance from the Oswego dam to the entrance of this harbor is about one and one-half miles. It is therefore apparent that should a twenty-foot waterway be constructed through the State on the route under consideration, a large amount of work would need to be done within these harbor lines at Albany and Oswego, but as that is work within the jurisdiction of the national government, it may safely be left for that government to perform.

When we remember, as stated in the report of ex-State Engineer John Bogart, the traffic on the Hudson river is more than double that of the Mississippi, Missouri and Ohio rivers combined, and that while many millions of dollars have been spent by the national government in improving these rivers, comparatively nothing has been spent by that government in improving the Hudson prior to 1892, it seems certain that Congress will do its share toward so great an improvement as the one under consideration.

At West Troy it is proposed to build a lock having a lift of twenty-four feet. By constructing a few hundred feet of low embankment, the Mohawk basin, a former outlet of the Mohawk river, can be made to contain the first level of the canal.

Passing up the old channel toward Cohoes, a low dam will be found necessary between Green and Van Schaicks' Islands, and another between Simmons and Van Schaicks' Islands.

Between Simmons Island and Cohoes the channel is just about wide enough for the construction of a lock, which, with another lift of twenty-four feet, will raise the second canal level to the present pond above the State dam at Cohoes. It will be necessary to extend this dam down to Simmons Island, and to remove its southern end to make a channel. By allowing this pond to remain at its present elevation the Champlain canal will not be disturbed, and it can continue to pass down through the Albany lumber district as at present.

A large scale map showing this portion of the route accompanies the report.

By means of a heavy rock cut this level can be extended to the foot of the Cohoes falls. It is proposed to build a dam fifty feet high on the crest of the falls, making one vertical lift of 130 feet to be operated by a huge counter-balanced tank in a manner similar to that used in building elevators. The level thus created would extend to the foot of the West Troy Waterworks Co.'s dam, above Dunsbach's Ferry. Here a dam nineteen feet high is proposed and a lock with a nineteen-foot lift. This dam would back water to Vischers' Ferry, where another dam and lock with the same lift (nineteen feet), would raise the water to an elevation of 216 feet. A level of this elevation would pass the city of Schenectady.

At Scotia, near Schenectady, it is proposed to leave the river channel, and by making a thorough cut 1.66 miles long, to avoid a large bend. At each end of this canal, a lock having a lift of twenty-two feet is planned, and at the upper lock where the route re-enters the river, a large dam would be needed. To follow the river around this bend would make a very crooked channel and require much dredging in gravel, and it is probable that the channel would fill up quickly at every stage of high water. Below Schenectady nearly all excavation would be rock, and as no large streams enter the river there, it is not likely that the channel would fill up in a great many years. The elevation, 216 feet, is about four feet below the crest of the banks at Schenectady, and as the floods which occur at that place sometimes rise about sixteen feet higher than the banks, it is apparent that no damage will be done by the back water, save in times of flood, which condition will be discussed later.

The crest of the dam last mentioned would have an elevation of 260 feet, and the level created by it would extend to a point just east of Amsterdam. There another dam and lock having a lift of eleven feet are proposed.

The next dam and lock have been located at about three-fourths of a mile east of the mouth of Schoharie creek. The lift of the lock would be nineteen feet. This dam would back water to a point about three and three-quarter miles east of St. Johnsville. There another dam and lock having a lift of twenty-one feet are planned, and the level above would extend just above the mouth of East Canada creek. There another dam and lock with a lift of nineteen feet would raise the water surface as high as the foot of the descent at Little Falls.

The valley at Little Falls is very much contracted and is composed entirely of granite rock. To make a radical enlargement in the present canal around the falls would be enormously expensive. It is therefore proposed to build two locks and dams right on the falls. By enlarging the present Little Falls feeder to the size of the Erie canal and removing the canal locks, a spillway could be formed around the falls which would readily discharge all the surplus water in the river and leave the main channel quiet and undisturbed for navigation.

A large scale map, showing the river, the Erie canal, and the proposed enlargement of the feeder at Little Falls, accompanies the report.

The crest of the upper dam at Little Falls should have an elevation of 370 feet, which is about the same as that of the surface of Oneida lake. It is then proposed to make a great cut through Utica and Rome, deep enough for a summit level to extend from Little Falls to and beyond Brewerton, on the westerly end of Oneida lake.

The channel of the river can be used as far as Ilion, but beyond that place the cross-section of the stream is so small and its channel is so tortuous that it has been disregarded and the estimate has been made for the excavation of the entire canal section from Ilion to Oneida lake. The route of the river is followed, how ever, as far as Stanwix, near Rome. There the proposed line diverges from the stream and runs south of Rome directly to Fort Bull, on Wood creek and then follows that creek to Oneida lake.

A dam and guard lock having a maximum lift of ten feet are located just east of the mouth of West Canada creek, near Herkimer. This is the first large tributary to the Mohawk above Little Falls, and it is proposed to receive this creek and all streams above it into the summit level, and store their waters to a height of ten feet. The average depth of the lake is said to be twenty feet, and in some places it is sixty feet deep. The water surface would be permanently raised about three feet above low water, but it is likely that even then some dredging will be needed. After crossing the lake, the route passes down the Oneida river a short distance, then it leaves the river, cuts off a large bend, then crosses the river and passes through a high but narrow ridge of ground. At the river crossing a dam is planned to raise the lake level about thirteen feet.

On the western side of the ridge just mentioned is located a combined lift and guard lock, having a maximum lift of twenty feet and a minimum lift of ten feet. At this lock the descent to Lake Ontario begins. Continuing, the route passes along the southern edge of a large piece of wet land known as "Peter Scott's Swamp." At one place where the swamp borders Oneida river, the route enters the stream and continues therein for about one-half mile. It then leaves the river channel, continues along the swamp, passes just north of Phoenix and enters the Oswego river below Phoenix dam, near the mouth of a small creek known as Brandy brook. The channel of the Oswego river forms the remainder of the route to Oswego. At Oswego Falls a dam is proposed that will back water to the crest of the Phoenix dam and up the canal to the combined lift and guard lock before mentioned. A single lock will suffice to reach the level below the falls. The next dam and lock are located a few miles above Minetto, and the next and last dam and lock in the city of Oswego. This last dam will raise the water about sixty-five feet above low-water in Lake Ontario. It is proposed to use here another elevator lock like the one at Cohoes. The lock will be partly within the lines of the Oswego harbor and it is considered the end of the canal.

WATER SUPPLY.

Every lockage into or out of the summit level will draw water from that level. On any other level if a boat draws water therefrom on entering at its lower end, it will also draw water into the level when passing out at its upper end. It is, therefore, apparent that the water supply is most likely to be deficient on the summit level, and that if the supply of that level is large enough the supply of other levels will probably be plentiful.

It is true that if the lift of a lock at the end of the summit level is not as great as the lift of the lock farther down the canal, then the lower lock will require the larger amount of water to pass a boat, but being further down stream, it is supplied by a larger watershed and, therefore, has a larger supply than the lock at the end of the summit level.

It is usual to consider three demands upon the canal water supply: lockage, leakage and evaporation. The demand for lockage is capable of exact theoretical determination, but the quantity used in practice would always be larger because of waste around the gates.

The demand for leakage is variable and is determined chiefly by the character of the canal banks. With a summit level as planned, the channel being so much below the surface, would, instead of losing water by leakage, gain water from the drainage of all water-bearing strata intersected in the excavation. The only leakage would be at the dam, lock gates and possibly a few small dykes on the south side of Oneida lake.

The ground drainage would probably more than compensate for these small losses.

The evaporation from any water surface in this locality exceeds the precipitation by about eight inches in depth during the navigation season. We will consider it to be one foot. To compute the demand for lockage, it is sufficient to estimate the cubical contents of each lock at the ends of the summit level and to consider that each lock will be emptied every thirty minutes. Lock No. 14 is a guard lock, having a maximum lift of only ten feet, so instead of calling that the end of the summit level, lock No. 13 at Little Falls is considered to be the end.

Lock No. 13 has a lift of twenty feet, and consequently will require twice as much water as lock No. 14 when making the maximum lift. Lock No. 15 is at the other end of the summit level and has a maximum lift of twenty feet.

The cubical contents of both locks is, therefore, 450x60x40= 1,080,000 cubic feet. Dividing by thirty gives 36,000, the maximum number of cubic feet per minute required to operate both locks. No allowance has been made for the water displaced by passing boats and none for leakage of gates. One would approximately offset the other.

Now, we have to consider the available supply. The present supply of the summit level of the Erie canal is about 33,000 cubic feet per minute, all of which would be available for the proposed canal, and as it is mostly stored water, it would be independent of the rainfall during navigation season.

The area of the Mohawk watershed above Little Falls is 1,272 square miles. The drainage area of Oneida river is 1,421 square miles. Assuming the drainage area of Oneida lake to be one-half that of the river, it would be about 700 square miles. The total drainage area of the proposed summit level is, therefore, about 1,972 square miles.

The flow per second per square mile, from the Oswego watershed and also from the Mohawk watershed, is 23-100 cubic feet in the dryest season.

For an area of 1,972 square miles, this rate would afford a flow of 454 cubic feet per second, or 27,240 cubic feet per minute. Adding this to the present storage supply of the summit level of the Erie canal, 33,000 cubic feet per minute gives 60,240 cubic feet per minute, which is the present available supply for the proposed summit level.

But it is proposed to also use Oneida lake as a storage reservoir to regulate the discharge of both the Oswego and Mohawk rivers. The storage depth as planned is ten feet. If one foot is deducted for evaporation there will remain nine feet available to regulate the flow of the rivers.

The area of Oneida lake is about eighty-one square miles and a storage depth of nine feet over that area will furnish a flow of about 67,000 cubic feet per minute continuously for seven months.

At present the ordinary spring floods on Oneida lake are sufficient to raise the water surface five or six feet. If the drainage of the larger watershed of the Mohawk above Little Falls was turned into the lake, the spring floods would certainly raise the water surface ten feet. From these facts it is apparent that the sufficiency of the water supply is absolutely unquestionable.

By using a higher summit level near Rome, and more locks, it would be possible to avoid a large amount of excavation, thus cheapening the cost of the canal.

The summit level would then be much shorter and have an area too small for storing any considerable quantity of water, and it is doubtful whether the supply would be plentiful for ordinary locks. Inclines or elevators could be built that would use very little water, and the available water could be made to suffice; but the plan proposed would give an abundance of water and much more certain results.

THE EFFECT OF FLOODS.

It has been objected that to dam the Mohawk river high enough for a system of slack water navigation giving a minimum depth of water in its channel of twenty feet, would cause the water in times of flood to rise high over its banks and to do an endless amount of damage. Is that true? The elevation of the bed of the Mohawk at Rome is 424. The water surface of the proposed summit level would have an elevation of 370, or it would be fifty-four feet lower than the present bed of the river. At

Utica the elevation of the river banks is about 400, which is thirty feet higher than the proposed water surface. The cross-section of the proposed waterway is larger than the cross-section of the Mohawk river anywhere between Ilion and Rome. Sections of the river and proposed canal at each of these places have been platted and accompany the report. It is therefore certain that Rome and Utica would obtain absolute protection from floods. With the existing conditions each city suffers large damage from flood every year. As all water falling in the Mohawk basin above Little Falls would enter the summit level, that entire level, with its eighty-one square miles of water surface, would have to rise as much as the water on the crest of the upper dam at Little Falls. Of course where any stream enters the canals the water would pile up a little, but not enough to alter the general condition. Any flood occurring above Little Falls would, therefore, have a slow and gradual discharge below the falls. The area of the Mohawk watershed above Little Falls is 1,272 square miles, above Cohoes it is 3,493 square miles; about thirty-six per cent. of the watershed would therefore drain into the summit level and the water be held back above Little Falls.

Below the falls each dam could have a movable crest similar to the Davis Island dam in the Ohio river. The crest of each dam below the falls would be much longer than its base and water one foot deep on its crest would afford a greater area of discharge than the same depth at the bed of the stream does now.

In the Engineering News for July 25th, 1895, was described the Goulburn dam, which is located on the Murray river in Australia. This river has a drainage area a little greater than the Mohawk and the variations of flow are greater than those of the Mohawk, but the water surface above the dam has been so well controlled that its elevation has not varied more than two inches in two years.

The description shows very nicely what can be done in the way of regulating the flow of streams. Considering these facts, it seems probable that all places below Little Falls as well as above, would escape future flood damage.

It is possible that on the longer levels below Little Falls, a surface inclination sufficient to discharge the maximum flow would make the water at their upper ends high enough to overflow the banks, but that is a question that can best be answered when the notes of a complete instrumental survey are available.

Sometimes a flood is caused at Schenectady by an ice gorge. It is doubtful whether that danger would be entirely removed, but it would not be as great after the construction of the dam above Schenectady as it is now.

At all places where streams enter the canal it would be necessary to provide some protection against the silting up of the canal. No estimate has been made of the cost of such protection, it being included in the percentage allowed for engineering and contingencies.

This discussion makes it appear that instead of creating danger from floods, the canal would serve to regulate and control the flow and afford absolute protection to all places above Little Falls and to diminish the danger of floods below that place.

EXCAVATION.

The quantity of excavation required in the river beds is not large, but it is mostly rock. The first cut estimated is near Green Island, where it is necessary to straighten the existing channel. The site of this cut shows nothing but soil which is certainly four feet deep, but the shale rock is so abundant in that vicinity, and is so frequently only covered by a very thin layer of earth, that it was thought best to classify the whole cut as rock.

It is probable that a portion of the next cutting, between that just mentioned and lock No. 2, is also earthy, but it is now under water and to insure against under-estimation it is called rock. All excavation between the proposed lock No. 1 and the present Cohoes dam can be drained. The rock is a soft shale and quite easy to excavate.

From the dam just mentioned to the Cohoes falls, a very large cut in solid rock has been planned. This cut could be avoided by using another dam and lock just above the D. & H. R. R. bridge, but it is believed that the cost thereof would be greater than that of the cut. It is probable that this cut too could be drained or partly so to facilitate the excavation.

All excavation from the Cohoes falls to and including Rexford Flats is in hard shale rock, the cutting is light, and while the work can not be entirely drained, it is partially exposed in dry weather and will not be as difficult as work done under several feet of water.

The material to be excavated just above the present Rexford Flats dam is probably a deposit caused by the dam, but this is not certain, and as the rock foundation of this dam is above the supposed canal bottom, it is possible that the rock extends up stream through the entire cut, so this too is classified as rock.

The next excavation begins at Scotia, on the opposite side of the river from Schenectady, and leaving the river, extends up the canal to the next dam. From an inspection of the river bank and an inquiry from people living in the locality, it seems quite certain that this cut is all earth and has been so classified.

The excavation between Amsterdam and Tribes Hill, stations forty-one to forty-three, is partly and perhaps wholly gravel, but no definite knowledge has been obtained about it, and since the river banks in that vicinity are largely composed of limestone, it is deemed best to call the whole cut rock. This excavation would probably be done under water.

The next three cuts, located near Canajoharie and St. Johnsville, are in all respects similar to the last and were classified in the same way.

The next cutting is at Little Falls. There the rock is a seamy granite. The cut is not large comparatively, but it is very hard to excavate and perhaps ten per cent. of it is under water and can not be drained.

The great cut, which extends from the falls to Oneida lake, contains about 80,000,000 cubic yards and upon the character of material found therein depends the feasibility of the plan, for if it were rock, the great cost of excavation would be prohibitory. It has been classified as earth and estimated at twenty-five cents per cubic yard. It has been shown on the Chicago Drainage canal that very hard material can be handled for that price.

No direct evidence of the nature of this material has been secured save on the surface, and as the cut is to be about eighty feet deep at Rome, surface indications alone might be valueless. However, the structure of the earth and the arrangement of the strata in this locality have been very carefully investigated by geologists, and they are firm in the belief that the whole valley above Little Falls consists of a vast deposit of gravel and silt. It is supposed that at one time Lake Ontario covered a large part of Central New York and found an outlet at Little Falls.

The route of the canal from Little Falls to Oneida lake follows this old waterway, and the material to be excavated was probably deposited by the water. An inspection of the profile shows how, at the head of each fall or rift, the rock dips downward and soon disappears as one passes up stream. This is also an indication of the absence of rock above Little Falls.

Above Ilion the channel of the river is so small and tortuous that no account of it has been taken in the estimate and profile. Whatever may be saved by using the river bed through this portion of the route would be more than offset by the expense of receiving tributary streams and protecting the canal prism against their deposits.

In all cases the ground has been considered level, transversely, and it is believed without great error. For a short distance between Fort Bull and Oneida lake the surface is quite rough and there the assumption will cause a small variation from the true quantities.

In Oneida lake probably some dredging will be needed, but it has not been estimated because no soundings were available.

Between Oneida lake and the Oswego river is a large cut, and it is perhaps more difficult to classify than any other. Most of the ground traversed is low and soft, but lock No. 15 is located on the western side of a high and narrow ridge which may contain rock.

At Phoenix the canal passes again through rather high ground, and at the entrance to the Oswego river there is rock that must be excavated under water. As a very rough approximation it is assumed that ten per cent. of the whole cut is rock.

All the excavation on the Oswego river is in sandstone and most of it must be removed from under water.

The following table gives a descriptive summary of the excavation and its estimated cost. The price of earth excavation is assumed as twenty-five cents per cubic yard, and has already been commented upon. The price for rock excavation is one dollar per cubic yard. While some of it may cost more than that, it is quite certain that the larger portion can be done for much less. Referring again to the Chicago Drainage canal, Mr. Isham Randolph, chief engineer, stated in a paper before the recent convention of the Deep Waterways Association, that the average price of rock excavation on that work was 76.31 cents and that the last 640,000 cubic yards had been let for fifty-nine cents per cubic yard.

The accompanying profile will assist in forming an idea of the extent and nature of the excavation. The points which have been determined instrumentally are indicated by small circles. Other parts of the profile were filled in from less reliable data, but in all cases where quantities are concerned it was endeavored to avoid guessing as much as possible.

Reference is also made to the cross-sections of the canal. It was assumed to be 100 feet wide on the bottom and to have side slopes of one and one-half to one inch in earth and vertical sides in rock.

TABLE OF EXCAVATION.

STATION TO STATION.	Cubic yards earth.	Cubic yards rock.	Remarks.
0—2+96	....	421,000	Mostly hard shale rock; small portion in earth.
2+96—4+10	....	467,000	Hard shale rock.
6+90—7+30	....	20,000	Hard shale rock.
10+0—10+13	....	8,000	Hard shale rock.
19+0—20+0	....	51,000	Hard shale rock; perhaps that portion above the present Rexford Flats dam is gravel.
23+80—25+66	630 000	....	Probably earth.
40+80—43+0	....	172,000	Bedrock in river, probably limestone.
49+60—65+80	....	1,557,000	Bedrock in river, probably limestone. There is a large deposit of gravel above Canajoharie, and a large part of this quantity may be gravel.
71+0—73+0	....	158,000	Bedrock in river, either limestone or granite.
79+07—80+45	....	246,000	Bedrock in river granite.
80+60—131+70	80,000,000	....	Deposit in old waterway.
154+50—165+30	5,889,000	654,000	Amount of rock uncertain.
172+20—173+0	....	75,000	Probably sandstone.
177+30—178+80	....	44,000	Probably sandstone.
	86,519,000	3,873,000	

86,519,000 cubic yards earth, at 25 cents	$21,629,750
3,873,000 cubic yards rock, at $1	3,873,000
Total excavation	$25,502,750

DAMS.

A cross-section of each dam site has been platted and the drawings accompany the report. The cross-sections at Dunsbach's and Vischer's Ferry are platted from the geological maps, excepting the river bed, which was determined with the stadia. The cross-section of the guard lock near Herkimer was made up from two sections taken a few miles on either side of the proposed site. All other cross-sections were taken with the stadia. Some of the locations are bad, but having been revised once, it is believed that they are good enough for the purpose. The method of estimating the cost was to determine the maximum height of each dam, and from that to calculate the area of its maximum cross-section, the section was then multiplied by the mean of the length of the crest and the base and the cubic contents thus determined was estimated at thirteen dollars and fifty cents per cubic yard. On some of the dam construction done by this Department the total cost of the masonry has been about seven-tenths of the total cost of the dams, so the above amount in dollars was divided by seven-tenths. This result was then compared with the cost of some existing dams of similar dimensions and modified according to the result of the comparison and also the peculiar conditions surrounding each site. When it is remembered that the estimate of any of these dams would furnish employment for a corps of engineers for a considerable length of time, it will be seen that these estimates are very crude.

The error in the total estimates will not be large enough, however, to affect materially the total for the whole canal.

Dam No. 1, from the head of Green Island to Van Schaick's Island, will have a rock foundation throughout. It must be built in several feet of water, which will cause considerable expense for bailing and draining, but there will always be a water cushion on either side of it and no apron will be needed. It is possible that the dam will need to be built higher than planned in order to prevent flood from going down the channel to lock No. 1. The estimated cost is $50,000.

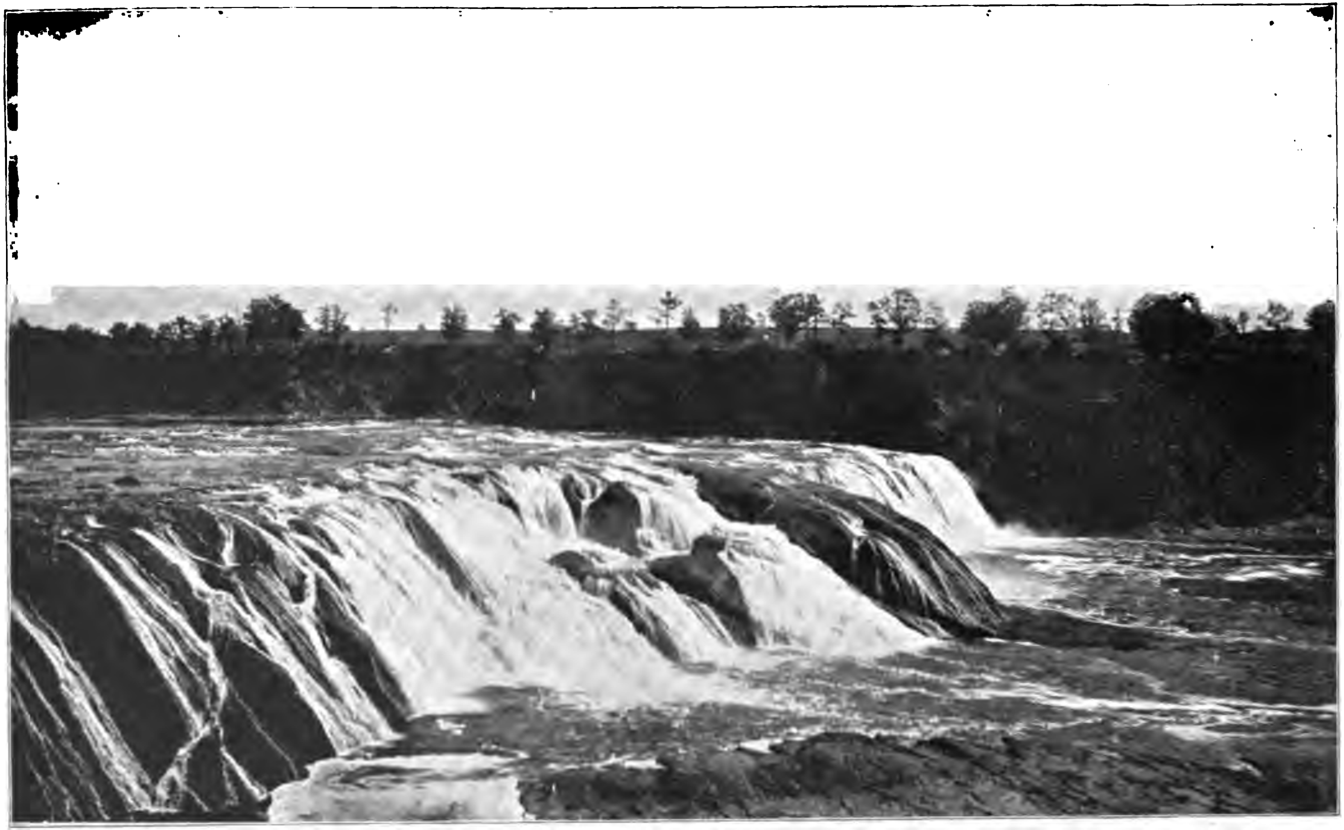
Dam No. 2, from Simmons Island to Van Schaick's Island, is in all respects similar to dam No. 1, save that it is much smaller. The estimated cost is $8,000.

Dam No. 3 is the alteration of the State dam at Cohoes. The foundation and one abutment is solid rock. The other abutment will be the present dam. The work can be started when the river bed is nearly dry, and the bailing and drainage will be inexpensive. The estimated cost is $175,000.

Dam No. 4 is located on the crest of the Cohoes falls, the foundation and abutments are solid rock and the work can be started when the water is so low as not to interfere with the work. The dam can not be completed in the dry season and the arrangements to take care of the water during the winter, will add to the cost of the dam. A photograph of this site accompanies the report. Estimated cost, $600,000.

Dam No. 5 is located near Dunsbach's Ferry. The foundation is rock but the dam extends a long distance across flat land to the bluff on the berme side of the Erie canal. There will be consider-

Falls of the Mohawk at Cohoes. Site of Dam No. 4.



Falls of the Mohawk at Cohoes. Site of Dam No. 4.

able earth excavation. It will not be necessary for the spillway to extend the full length of the crest and the construction can be cheapened on the low end. The work can be started with low-water, perhaps two feet deep in the river, and bailing and drainage will not be expensive. Estimated cost, $500,000.

Dam No. 6 is located near Vischer's Ferry. The river bed is rock. The banks are probably rock and the water is about four feet deep in dry weather. Estimated cost, $800,000.

Dam No. 7 is located a short distance above Schenectady. The bed of the river is gravel. The banks are probably rock. The water is about eight feet deep in dry weather. If the gravel in the river bed is very deep the dam would be enormously expensive and perhaps dangerous. A thorough examination would determine the necessary facts and if unfavorable, a new location would be needed. Estimated cost, $1,500,000.

Dam No. 8 is located at Amsterdam. The river bed and banks are probably rock. The water is about four feet deep in dry weather. Estimated cost, $300,000.

Dam No. 9 is located near Tribes Hill below the mouth of Schoharie creek. The river bed is probably rock. The crest extends over a wide piece of bottom land and there would be much earth excavation. The location could probably be improved by going down stream a mile. The water is not deep in dry weather. Estimated cost, $600,000.

Dam No. 10 is located near Fort Plain. The river bed is rock. The water is shallow in dry weather. The north bank is low and the dam would extend to the New York Central tracks and there would be considerable earth excavation. Estimated cost, $200,000.

Dam No. 11 is located just above the mouth of East Canada creek. The river bed is solid rock. The water is very shallow in dry weather. The crest of the dam will extend for a wide distance over the bottom land on each side of the river and there would be a large amount of earth excavation, but the spillway need not extend the full width of the dam. The estimated cost is $300,000.

Dams No. 12 and No. 13 are at Little Falls. The river bed is solid rock and no difficulty has been encountered in handling the water in dry weather during the construction of the two existing masonry dams at this place. The estimated costs are $40,000 and $55,000, respectively.

Dam No. 14 is located near Herkimer. The river bed and banks are probably all gravel, but the head of the water on the upper side of the dam would be only ten feet and it would be safe to build the dam in gravel if necessary. The estimated cost is $100,000.

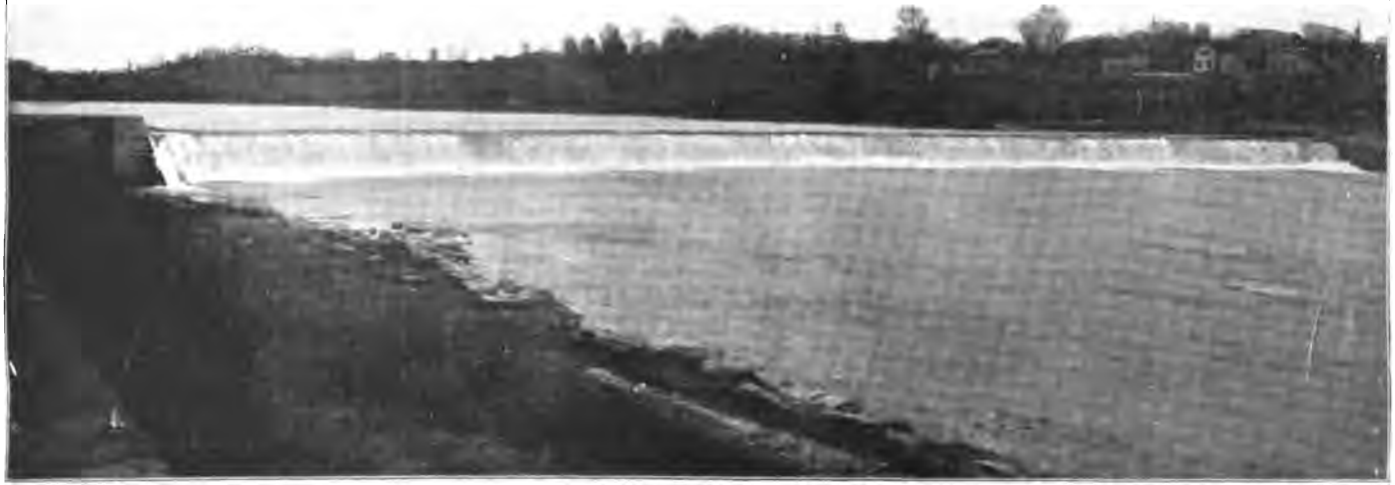
Dam No. 15 is located on the Oneida river between Caughdenoy and Oak Orchard. The river bed is probably rock. The water is very deep, not less than twenty feet. The estimated cost is $100,000.

Dam No. 16 is located at Fulton. The river bed is rock. The water is about eight feet deep. The banks are steep and probably rocky. Estimated cost, $350,000.

Dam No. 17 is located near Minetto. The characteristics are the same as for dam No. 16, save that the water is about two feet deep in dry weather. Estimated cost, $400,000.

Dam No. 18 is in Oswego. The river bed and banks are rocky. The water is about ten feet deep. The site is illustrated by the accompanying photograph. Estimated cost, $700,000.

The following table gives the location, character of foundations, general dimensions and cost of each dam.



Horseshoe Dam, Oswego. Site of Dam No. 18.

Horseshoe Dam, Oswego. Site of Dam No. 18.

TABLE OF DAMS.

No. of Dam.	LOCATION.	Character of Foundation.	Extreme Height.	Length of Crest. linear feet.	Length of Base. linear feet.	Area of Section Maximum. square feet.	Estimated Cost.
1	Head of Green Island	Rock	14.0	486.0	380.0	137.5	$50,000
2	East of Simmons	Rock	4.0	380.0	380.0	25.6	8,000
3	Cohoes State Dam	Rock	18.0	896.0	896.0	196.0	175,000
4	Cohoes Falls	Rock	50.0	1,380.0	745.0	1,095.5	600,000
5	Dunsbach's Ferry	Rock	34.0	2.300.0	700.0	537.0	500,000
6	Vicher's Ferry	Rock	44.5	2,042 0	814.0	876.0	800,000
7	Three Miles above Schenectady	Gravel	60.0	1,810 0	1,000.0	1,527 5	1,500,000
8	Amsterdam	Probably Rock	30.0	1,090.0	750.0	433.0	300,000
9	Tribes Hill	Probably Rock	30.5	2.850.0	1 100.0	446.0	600,000
10	One Mile above Fort Plain	Rock	30.0	1,180 0	240.0	433.0	200,000
11	East Canada Creek	Rock	31.0	2,100.0	300.0	459.0	300,000
12	Little Falls	Rock	23.0	300.0	80 0	283.0	40,000
13	Little Falls	Rock	12,0	950.0	950.0	116 4	55.000
14	Two Miles below Herkimer	Probably Gravel	17.0	1,080.0	450.0	180.0	100,000
15	Oneida River	Probably Rock	27.0	230.0	280.0	363.0	100.000
16	Oswego Falls	Rock	38.0	875.0	652 0	650.0	350,000
17	Minetto	Rock	45.0	820.0	400.0	895.0	400,000
18	Oswego	Rock	52.0	1,060.0	750.0	1,185 0	700,000
	Total						$6,778,000

LOCKS.

The size of the locks has been assumed to be 450 feet by sixty feet, the lift ranging from ten feet to twenty-seven feet. To repeat a little for the sake of clearness, locks having a lift of thirty feet were used on the Lehigh Valley canal and a common lock having a lift of fifty-three feet was proposed on the Nicaragua canal. The lift of the new lock at Sault St. Marie is nineteen feet. It does not appear, therefore, that a lift of twenty-seven feet is in any degree experimental. A more careful location of dams might reduce the maximum lift to twenty-four feet, and that should be done of possible.

The locks on the Nicaragua canal were planned to be 650 feet long and sixty-five feet wide between gate abutments, and eighty feet wide in chamber and were estimated to cost about thirty-six thousand dollars per vertical foot lift. The locks under discussion are smaller, they are located in a region where material and transportation are convenient and most of them have solid rock foundations. They have been estimated to cost $40,000 per vertical foot lift, the intent being here, as in all other parts of the discussion, to make the estimate high, rather than low.

Lock No. 1 is located at West Troy; it would have a maximum lift of twenty-four feet and would raise boats from the Hudson river into the first canal level. The foundation would probably be piles in gravel; with two exceptions, it is the most difficult foundation on the whole canal.

Lock No. 2 is located at Cohoes, between Simmons Island and the city. Its lift is twenty-four feet, and the foundation is solid rock.

Lock No. 3 is located at the Cohoes falls. The lift at this place is 130 feet, and a huge tank suspended over pulley wheels and counter-balanced with water, operating something like a building elevator, has been considered the most practical means of overcoming it. A lift of that size would be unprecedented, but the novelty exists only in size, for in no case would members be as large nor would they be subject to as great strains as the members of the Eiffel Tower or the Brooklyn Bridge. There would be plenty of room to multiply the members so that smaller sizes could be used than one might expect at first thought. The cost of such a structure has not been studied at all, for it is very certain that the unit price proposed would cover this as well as common locks, and it was not considered worth the time to attempt to reduce the total estimate by paring it down on this lock. The foundation would be solid rock and the topography is well suited for the structure. The location is well shown in the accompanying photograph, taken by Mr. Leutze.

Lock No. 4 is located near Dunsbach's Ferry. It has a lift of nineteen feet and the foundation is solid rock.

Lock No. 5 is located near Vischer's Ferry. The lift is nineteen feet and the foundation is solid rock.

Lock No. 6 is located at Scotia, and will raise boats from the river into the short canal level. The lift is twenty-two feet and the foundation is probably piles in gravel.

Lock No. 7 is near Rotterdam. Its lift is twenty-two feet and the foundation is either hard-pan or piles in gravel.

Lock No. 8 is at Amsterdam. Its lift is eleven feet and the foundation is probably rock.

Lock No. 9 is at Tribes Hill. Its lift is nineteen feet and the foundation is probably solid rock.

Lock No. 10 is above Fort Plain. Its lift is twenty-one feet and the foundation is probably solid rock.

Lock No. 11 is at East Creek. Its lift is nineteen feet and the foundation is probably solid rock.

Locks Nos. 12 and 13 are at Little Falls. The lift of each is twenty feet and the foundation is solid rock.

Lock No. 14 is east of Herkimer. It is only a guard lock with a maximum lift of ten feet. The foundation is probably piles in gravel.

Lock No. 15 is east of Phoenix. It is a combined guard and lift lock. The maximum lift is twenty feet and the minimum ten feet. The foundation is probably hard-pan or rock.

Lock No. 16 is in Oswego river at Fulton. The lift is twenty-six feet and the foundation is solid rock.

Lock No. 17 is located a short distance above Minetto. It has a lift of twenty-two feet and the foundation is rock.

Lock No. 18 is in Oswego. Its lift is sixty-five feet and the foundation is solid rock. Here another steel lift similar to the one at Cohoes, has been planned. This is the last lock and it will lower boats directly into the Oswego harbor. The location is illustrated in the accompanying photographs taken by Mr. Leutze.

The dam shown is the present State dam which feeds the Oswego canal down to the basin in the harbor and also a water-power canal on each side of the river. The location for the proposed dam is a short distance above this dam, the bluff forming the western abutment being shown on the far side of the river.

The accompanying table gives the number of each lock, its distance from the preceding lock and the lift.

The total number of vertical feet lift is 518. At $40,000 per foot the total cost amounts to $20,720,000, which amount has been used in the estimate as the cost of the locks.

A summary of data concerning the locks is given in the following table:

TABLE OF LOCKS.

Number of lock.	Lift in feet.	LOCATION.	Distance from preceding lock.	Character of foundation.	Remarks.
			Miles.		
1	24	West Troy			
2	24	Cohoes	2.96	Piles in gravel	
3	130	Cohoes Falls	1.14	Hard shale rock	Elevator lock.
4	19	Near Dunbach's Ferry	6.03	Hard shale rock	
5	19	Vischer's Ferry	5.02	Hard shale rock	
6	22	Scotia	8.85	Piles in gravel	
7	22	Rotterdam	1.66	Probably piles in gravel	
8	11	Amsterdam	11.84	Probably rock	
9	19	Tribes Hill	5.50	Probably rock	
10	21	Fort Plain	22.80	Probably rock	
11	19	East Creek	7.20	Rock	
12	20	Little Falls	6.40	Rock	
13	20	Little Falls	.76	Rock	
14	0–10	Herkimer	4.84	Piles in gravel	Guard lock.
15	10–20	East of Phoenix	73.90	Probably hard pan	G. and L. lock.
16	26	Fulton	13.28	Rock	
17	27	Near Minetto	5.12	Rock	
18	65	Oswego	5.20	Rock	Elevator lock.
Total	518		182.50		

There is an abundance of good limestone and sand along the route, and it is probable that much of the excavated rock could be used in concrete. The facilities for transportation are excellent. The New York Central Railroad and the Erie canal parallel the route from Cohoes to Schenectady. The West Shore and the New York Central Railroads and the Erie canal parallel the route from Schenectady to Rome, the Rome & Watertown Railroad and the Oswego canal parallel the route from Phoenix to Oswego, and the portion of the route between Fort Bull and Phoenix is accessible by the Rome and Watertown Railroad and the Oneida river and Oneida lake.

Most of the structures are located remote from improved property where storage room is abundant and cheap.

BRIDGES.

All existing bridges over the proposed route will need to be provided with a pivot pier and draw span, and whenever the canal leaves the natural waterways, all intersections with highways and railroads will require new bridges.

The existing bridges are as follows: Thirty-eight highway, six single track railway, two double track railway, and three four-track railway. There will be needed besides these, fifteen new highway bridges, one single track railway bridge and one four-track bridge. The expense of building a bridge varies so much with the topography of the country, the character of the foundation and height of the piers, that a survey of each site would alone render an exact estimate possible. It was not practicable to make such surveys and so the following prices were adopted as the average cost of each style of bridge:

Highway drawbridge	$20,000
Single track railway drawbridge	30,000
Double track railway drawbridge	50,000
Four-track railway drawbridge	100,000

These prices may appear excessive, but they are supposed to cover changes of grade, and all other alterations and improvements necessary.

The estimated cost of all bridges required is as follows:

53	Highway bridges	at	$20,000	$1,050,000
7	Single track railway bridges	at	30,000	210,000
2	Double track railway bridges	at	50,000	100,000
4	Four-track railway bridges	at	100,000	400,000
66	Total			$1,770,000

The railroad bridge at Brewerton has a draw giving a clear opening of about sixty feet, and it may not require any expensive alterations. It is not included in the estimate. Some of the intersecting highways can probably be altered so that two or more may cross one bridge and thus reduce the estimated cost by a small amount.

PROTECTION OF SLOPES.

A canal prism is subject to three independent disturbing influences. The flow of water through the canal tends to erode the banks and the swells of passing boats wash the banks near the water line and tend to flatten the slopes, and the screws of propellers tend to deepen the center of the channel by the excessive agitation of the water near the canal bottom. This agitation raises the earth which settles again in the quiet water near the toe of the side slope and thus flattens the slope and lessens the depth of water at the sides of the prism. It is not expected that the flow of water in the proposed canal will be great enough to cause any trouble by erosion of the banks. The deepening of the channel in the center by propeller screws has not been successfully prevented so far as the writer knows, and any attempt in that direction would probably be made by elevating the screws or by using side wheels.

To protect the slopes from wash by waves, many devices have been used with varying success. The most common plan is to pave the entire slopes thoroughly with large stones, but in the case of the great cut through Rome the expense of such a plan is prohibitory. It is proposed to drive a row of piles on the slope at such a point that when the top of the piles are at the water surface the length above ground will be about five feet; the piles to be driven close together, the tops confined by wale pieces and anchored to the banks and the space in the rear filled with riprap. On the summit level there should be two such rows of piles, one located from the low water surface and one from the high water surface.

The lower row of piles being always submerged, would not decay. The upper row would last a great many years, but if necessary it could be replaced easily when the water is low. In ordinary hard earth such a protection would be very efficient. In very soft earth, sheet piling might be needed, or perhaps the excavation would need to be increased to obtain a flatter slope.

The estimate of this means of protection for the total length of canal prism (48.78 miles) is as follows:

Single line of pile revetment, 4.98 miles:	
52,589 12 in. dia. piles 15 feet long, at $3.00......	$157,767 00
525,888 feet B. M. 6 in. by 10 in. at $20 per M....	10,518 00
65,740 cu. yds. riprap at $1.50..................	98,610 00
52,589 29 in. by 7-8 in. bolts at 4c. per lb..........	12,249 00
Double line of pile revetment, 43.80 miles:	
924,956 12 in dia. piles 15 feet long, at $3.00....	$2,774,868 00
9,250,560 feet B. M. 6 in. by 10 in., at $20 per M..	185,011 00
1,156,195 cu. yds. riprap at $1.50................	1,734,293 00
924,956 29 in. by 7-8 in. bolts at 4c. per lb........	215,441 00
Total..................................	$5,188,757 00

LAND DAMAGES.

The expense that is customarily charged to this account may here be divided into three parts, viz.: The value of land flooded and used for the canal and for spoil banks, the cost of raising railroad tracks where necessary, and the damage to water power.

The area of land to be flooded has mostly been obtained with a planimeter from the United States geological maps. From Fonda to Little Falls the area was estimated from the cross-sections of the river valley. On some few places like the north shore of Oneida lake not covered by the maps, no measurements were possible and the area was simply guessed at. On the Oswego river the area was determined from the cross-sections taken for dam sites. The area required for the canal and spoil banks was estimated according to the depth of cutting and made wide enough to avoid overloading the banks and causing them to slide.

A list of the land required for these purposes at each locality along the route, was prepared and submitted to Mr. P. McNamara, who has had many years' experience in defending the State against claims arising from the canals.

After a careful consideration he has decided that an average price of $60 per acre will be ample compensation for the land taken. Three and four-tenths miles of single track railroad at Sylvan Beach would be rendered worthless, and it has been estimated at $6,000 per mile.

Without giving a detailed statement it is sufficient to state that the estimate arrived at in this manner amounts to $2,788,263.

For raising track the estimate is made as shown on the profile, but it also includes several miles of single track around Oneida lake.

The filling required is estimated at thirty cents per cubic yard, this price being large enough to cover the cost of resurfacing. The total amount is $430,000.

The damage to existing water powers would cost the State considerable money, but many new powers would be created; the total value of the new powers would largely exceed the value of those now existing, and it is considered the sale of these powers would more than pay for the necessary changes in, and destruction of, the present water powers.

At Cohoes the total fall of the water would be greatly increased and as the special lock to be used there would require very little water, nearly the whole flow of the Mohawk would be utilized for power. Adding to this advantage the steady flow resulting from the storing of the water in Oneida lake, it is readily seen how much more valuable the power at Cohoes will become. Besides this, the present Erie canal, situated high above the proposed water surface, can be used as a water-power canal and will become a very valuable property.

At Little Falls the change in the location of dams will cause a large expense for the rearrangement of flumes and races, but the total fall of water will be increased and the flow rendered more steady and continuous. The same may be said of the powers at Fulton.

At Oswego the construction of the proposed dam and special lock will increase the value of the present power fourfold, without necessitating any great change in the present arrangement of canals.

The total expenses under this head is, therefore:

Land appropriated	$2,788,263
Raising track	430,000
Total	$3,218,263

The abandonment of the Erie canal through the cities along the route would not only make the land which it now occupies available for building sites, but would greatly enhance the value of adjacent property. Although no deduction is made from the estimate on this account, it is plain that the change would be worth a large amount to the cities thus benefited.

It is not possible to carry the estimate for the canal any further at present. Although there may be many omissions, with one exception their total would be comparatively very small.

The exception is an electric lighting plant which could be run entirely by water power and would make navigation as easy by night as by day.

The addition to the total estimate as is now stands, of thirty per cent. for engineering, contingencies and omissions, makes a final result that may be considered to be very near the correct amount, and it may be safely used in studying the financial possibilities of the scheme.

A summary of the estimate is here given:

TOTAL COST OF ENLARGED CANAL.

Quantities.		Amount.
86,519.000	Cubic yards excavation of earth, at 25 cents	$21,629,750
3,873,000	Cubic yards excavation of rock, at $1	3,873,000
18	Dams, average cost $376,278	6,773,000
518	Feet lift of locks, at $40,000 per foot	20,720,000
65	Bridges, all kinds	1,750 000
	Protection of slopes	5,188,757
	Land damages	3.218,263
		$63,152,770
	Engineering and contingencies, 30 per cent	18,945,831
	Total	$82,098.601

CONCLUSION.

In conclusion, a summation of the merits of the proposed plan is as follows:

The use of slack water navigation makes a greater depth of water at the lower end of each level than at the upper end, by reason of the slope of the river bed, so that out of 182.5 miles of canal 33.4 miles, or eighteen per cent. of the whole, will have a depth of at least twenty-five feet, making navigation easier and safer than where there is only about two feet of water under a boat's keel, as there would be with only twenty feet of water in the canal.

The length of Oneida lake is included in this percentage of canal that is twenty-five feet deep.

The width of the water is greater than canal section for seventy-three per cent. of the whole distance, thereby avoiding the piling of water in front of a steamer and retarding its speed, a difficulty which always occurs in canals of small width. These two features will permit greater speed than can be obtained in ordinary canal prisms.

Only two per cent. of the whole length is raised above the surrounding country by canal banks, thereby reducing leakage and danger of breaks in the banks to a minimum.

Absolute protection against floods is afforded to all property between Little Falls and Oneida lake, which will result in a large annual saving in flood damages.

The creation of new water powers, larger than any at present existing in the State save at Niagara Falls, and the regulation of the flow of water so as to be continuous during the dry season, will add enormously to the resources of the State. Now that electric transmission makes water power available for a considerable distance from its source, we may expect a large increase in its use and a corresponding decrease in the use of coal.

The cities and villages between Little Falls and Rome will have better drainage than at present. In Rome especially, the present drainage is poor.

The removal of the present canal with its bridges, leaks and danger of breaks from the cities of Rome, Utica, Schenectady and Cohoes, will be worth several millions of dollars to those cities.

The canal being wholly within the territory of the United States, will be far more valuable as a source of revenue and for military purposes than if it were partly in Canadian territory.

Should it be deemed best to build a channel fourteen feet deep instead of twenty feet deep, the locks and dams could be used as planned, and the quantity of excavation reduced. This would effect a large saving in first cost and the canal could be deepened to twenty feet whenever desired.

The greatest difficulties to be encountered are the great cut through Rome, the controlling of the flood waters below Little Falls, and the operation of the elevator locks. These are large engineering problems, but probably few engineers will consider them incapable of solution.

The estimate of cost is believed to be high, rather than low, and when compared to the cost of our leading railway systems it is seen that instead of being in any degree fabulous it is well within the bounds of practicability.

The result of the investigation seems therefore to be greatly in favor of the route described and a more exhaustive study is certainly desirable.

It must be remembered that the time and money available for this work were very limited and that such a study would doubtless discover many desirable changes in the proposed plan. As before stated, the work is only the first preliminary, and as such alone should it be considered. It will, however, furnish an excellent guide for further study, and in case of a demand for an accurate survey, much time may be saved in planning details by a use of these data.

In discussing the economy of building such a waterway, it would be well to consider the history of the Suez canal. That canal cost in round numbers £20,000,000. To-day the profits of the canal have been so enormous that its stock is worth £80,000,000. But the traffic passing through the Detroit river to-day is not only greater than any traffic that ever passed through the Suez canal, but greater than the traffic passing through any other single channel in the whole world. This traffic is mainly domestic and is carried on almost wholly between Chicago, Duluth and the upper lake ports on the one hand, and Cleveland, Buffalo and the lower lake ports on the other. Such being the present condition of traffic, what might we expect if the same waterway were extended to connect Albany, New York, Brooklyn, Jersey City and Philadelphia with Buffalo, Cleveland, Detroit, Milwaukee, Chicago and Duluth? We need not consider the possibility of trans-Atlantic shipments from Duluth, but only the extension of our domestic commerce.

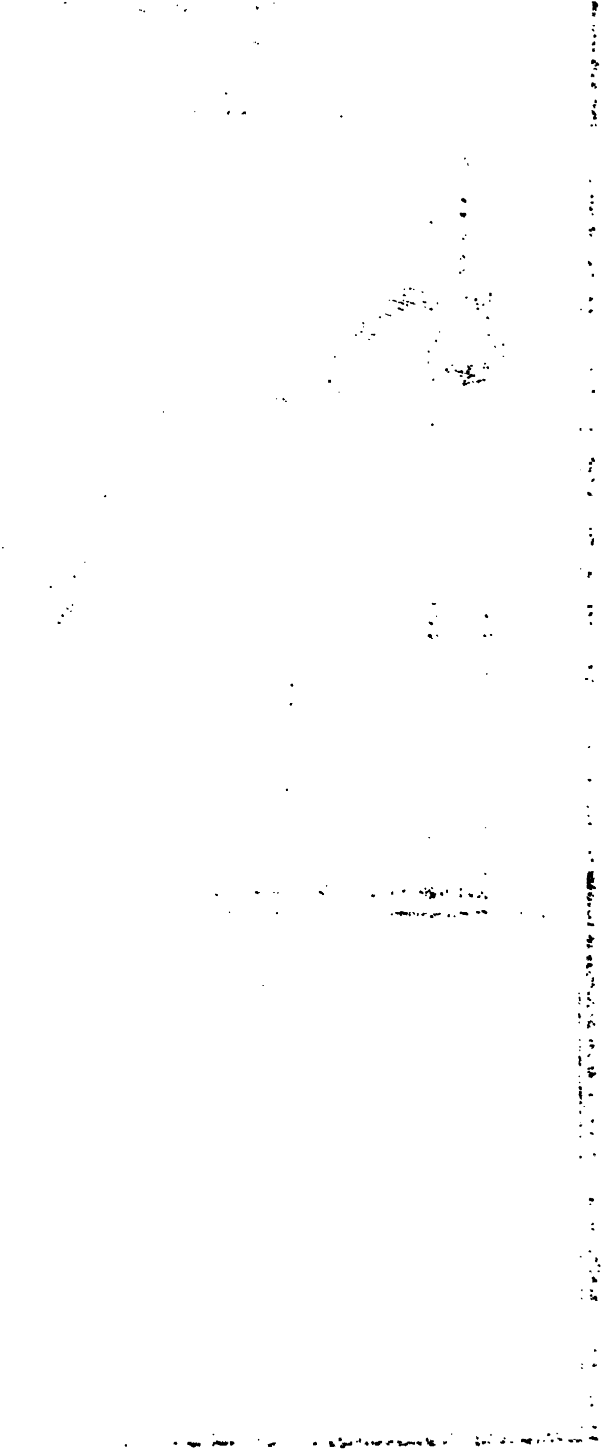
Turning now to the military aspect, it is idle to say that no war will ever come between this country and Canada, for the history of the world for all time is a succession of peace and war of varying duration. We hope it may not come; but if it does come, and this vast commerce and the wealth of the lake cities is unprotected, then may Heaven save us, our own hasty efforts can not.

With the present defenseless condition of this vast population and property it seems probable that, should the State of New

York undertake the construction of this canal, the national government would be more than willing, in consideration for the use of the canal for military purposes, to grant a large subsidy to the State, which would greatly assist in defraying the expense of construction.

It is a pleasure to acknowledge the assistance that has been received from Assistant Engineer Leutze and Messrs Hendrickson, Bagg and Jones, in the collection and preparation of material for the report. Much of the data was obtained from reports of former State Engineers, the Tenth Census Report on Water Power, the papers of the American Society of Civil Engineers and the United States geological maps.

Very respectfully,
ALBERT J. HIMES,
Resident Engineer, Eastern Division, New York State Canals.

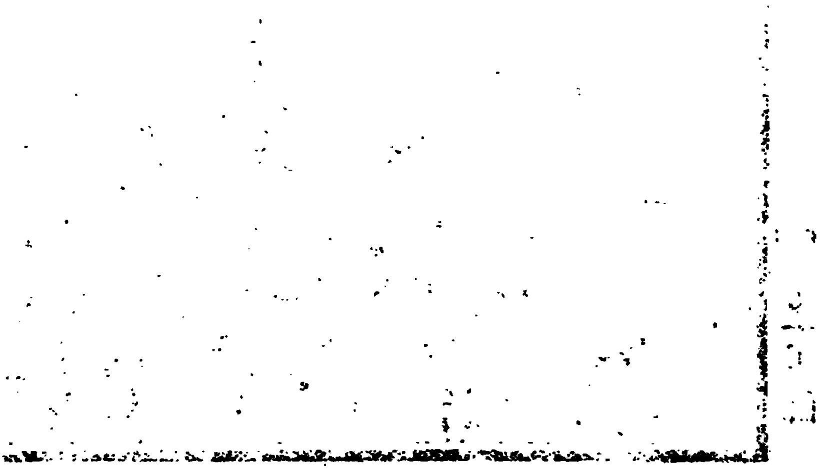


REPORT

ON

UPPER HUDSON

STORAGE.



REPORT ON UPPER HUDSON STORAGE.

ALBANY, N. Y., *December* 31, 1895.

HON. CAMPBELL W. ADAMS, *State Engineer and Surveyor*, and
HON. GEORGE W. ALDRIDGE, *Superintendent of Public Works:*

Gentlemen.—Chapter 599 of the Laws of 1895, provides that the Honorable State Engineer and Surveyor, acting in conjunction with the Honorable Superintendent of Public Works, shall as soon as practicable cause a survey to be made of the Upper Hudson valley, with a view of determining what lakes and streams may be improved, or the waters thereof stored or diverted, in order to provide (1) for an enlargement of the Champlain canal; (2) for restoring to the water-power of the Hudson river, at or below Glens Falls, the water diverted therefrom for canal purposes; and (3) for improving the navigation of the lower Hudson river. The supervision of the survey having been intrusted to me, I have the honor to herewith report in regard to this year's operations on the same.

I will not consume space in describing the basin of the Upper Hudson at length. Such description may be found in other publications,* and I will merely give enough here to make clear the present season's work.

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* See report on Water Power of the Hudson River Basin, by Dwight Porter, C. E., in Vol. XVI. of the Tenth Census (1880), where a description in detail of the Upper Hudson area may be found. Also see (1) Report Relative to a Survey of the Hudson River to Fort Edward and of the Champlain Canal Enlargement from Tide Water to Whitehall. by Samuel McElroy, C. E., Senate Documents, 1867, Vol. II., No. 37; (2) a Report on a Survey of the Waters of the Upper Hudson and Racquette Rivers, in the Summer of 1874, with reference to Increasing the Supply of Water for the Champlain Canal and Improving the Navigation of the Hudson River, by F. N. Benedict. Assembly Documents 1871, Vol. I., No. 6, p. 85.

Also see various reports of the U. S. engineers relating to the Hudson river.

NATURAL SUBDIVISIONS AND DRAINAGE AREA OF THE HUDSON RIVER.

The Hudson river naturally divides into two sections, the upper and the lower, at the Troy dam, which is now the head of the lower or tidal section, although before the erection of the dam it is probable that the tidal influence was felt as far up as Waterford.

The drainage area at Troy, as estimated from the State maps, is taken at 8,000 square miles; at Mechanicville, at 4,500 square miles, and at Glens Falls at 2,800 square miles. The Mohawk river, the longest tributary of the Hudson, has a drainage area of about 3,400 square miles. The next longest tributary below Glens Falls is the Hoosic, with a drainage area of 730 square miles. The Battenkill has a drainage area of 460 square miles.

Above Glens Falls the first tributary of importance is the Sacandaga, which joins the main river at Hadley. Its drainage area is 1,040 square miles.

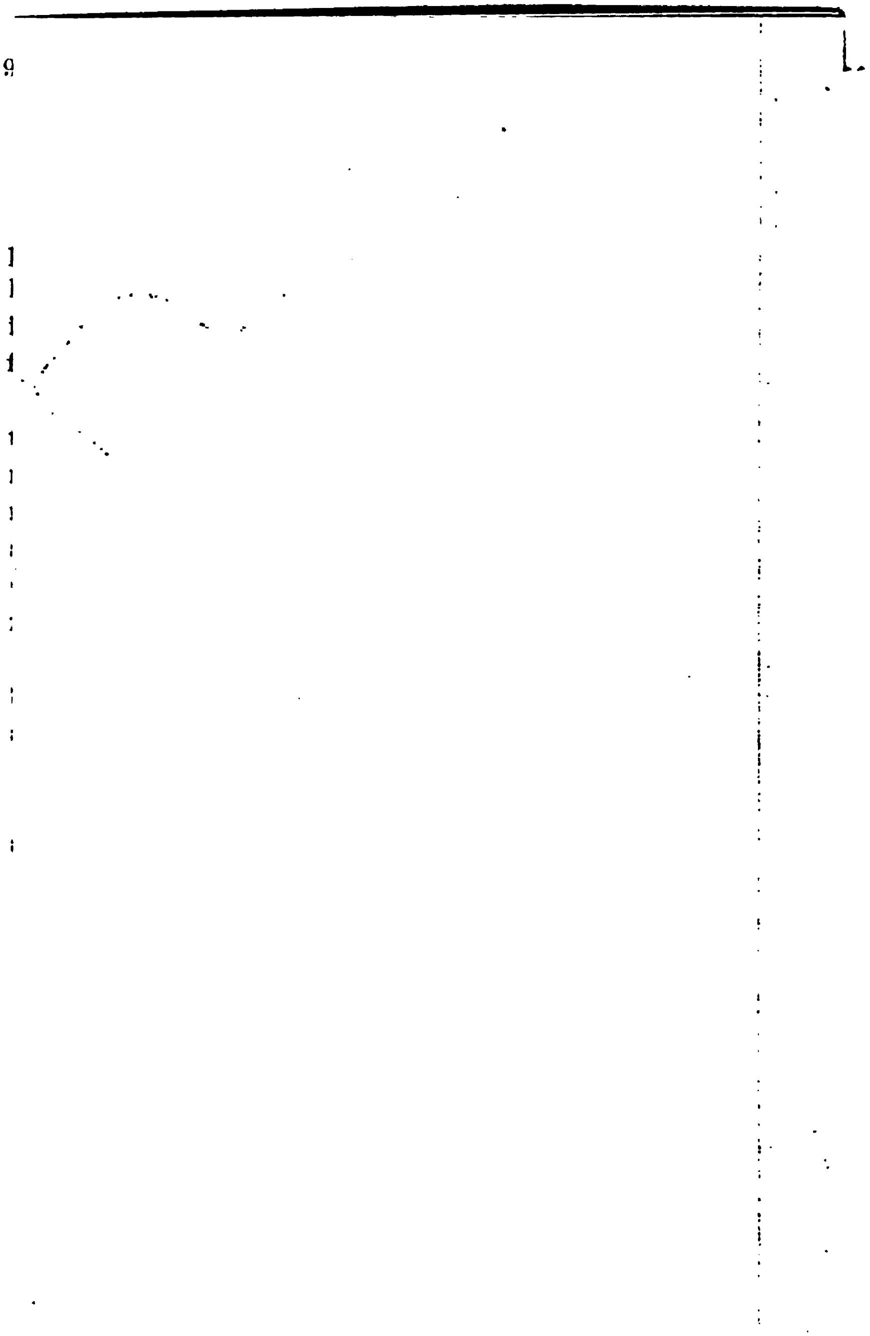
At Thurman we have the Schroon, with an area of 550 square miles. Plate I. is a general drainage area map of the portion above Glens Falls as compiled from the existing State maps.

The Champlain canal is fed from the Hudson river at Northumberland, and at Glens Falls, and as this latter is the highest point on the river from which water is taken for canal purposes, it may be presumed that the Legislature intended to direct that the examinations for the proposed reservoirs be made above the feeder dam at that place.

THE ORGANIZATION OF THE SURVEY.

Eight thousand dollars was the sum appropriated by chapter 599 for the purposes of this survey; and, inasmuch as this amount was utterly inadequate to giving all the information called for, it became a matter of some importance to decide just what to do, in order to best comply, so far as the money available would permit, with the mandate of the Legislature.

As already stated, the drainage area of the stream is taken at



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2,800 square miles above Glens Falls. This is a region of mountains, forests and lakes. Thus far the Commonwealth of New York has been unable to secure any maps of this region other than the very general ones, based upon crude and incomplete land surveys, made, in many cases, as much as one hundred and twenty-five years ago. And while such maps furnish a general outline of the region, they fail entirely, when one attempts to use them for determining the subdivisions of the main drainage area for an extended reservoir system with storage developed to full capacity, such as the Legislature evidently contemplated by the enactment of Chapter 599. In order to make this point clear, one need only to refer to those clauses of the bill which provide for the location of sites for dams and the establishment of lines of flow for securing the full storage available at the various sites; or further, to that wherein it is provided that the estimates of costs may be based upon the full development of the storage.

It was imperative, then, to have first of all a fairly complete topographical map of the drainage area above Glens Falls, and in order to accomplish this in the most expeditious and economical manner, the Honorable State Engineer and Surveyor made an arrangement with the United States Geological Survey to expend $4,000 of this appropriation, against $4,000 to be furnished by the Federal Government, on topographical surveys within the Upper Hudson drainage area. Under this arrangement surveys have been made of the drainage area of the Schroon river, so that for that portion of the Upper Hudson area we now have an accurate map. Plate No. II. of the accompanying maps has been compiled from the advance sheets of the Geological Survey's work.*

While these detailed topographical surveys were in process by the United States Geological Survey's corps of topographers, additional parties, working under my immediate direction, have been engaged in surveys of possible reservoir sites at points outside of as well as in the Schroon river area. Detailed surveys of locations for several dams have been made, together with a water-power profile of the Hudson river from the feeder dam at Glens Falls to North River village, a distance of sixty-five miles. Also a canvass of the water-power now actually in use on the river was completed; gages set at seven different dams in order to secure a record of daily flow for future use, and much other work accomplished, the significance of which will appear as we proceed. In addition, a thorough reconnoissance was made at the beginning of the entire area, in the course of which nearly every pond, lake or river valley was visited which could be in any degree considered available for storage purposes. This part of the work involved a journey by wagon of several hundred miles.

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* These maps are of the standard size of 12 1-2 by 17 1-2 inches, of all the atlas sheets of the United States geological survey, and form a part of the permanent topographical map of the State.

SCOPE OF THE STUDIES REQUIRED.

It may be easily concluded when one considers that this investigation demands, under the provisions of the act authorizing it, fairly exact knowledge of the amount of water required for supplying the enlarged Champlain canal, and the compensation therefor to be made, to the water-power on the Hudson river from Glens Falls down; and finally a determination of the possible improvement of the navigation of the tidal section, that the studies are necessarily of rather wide range. We need to know (1) the area of the several subdivisions of the drainage area, together with the locations and extent of the reservoir sites, as well as the total area from which the runoff may be controlled; (2) the rainfall and mean temperature of the tributary region as well as its physical characteristics, the relative amounts of timber and cleared area, etc.; (3) the actual runoff of the stream from the known area for a series of years, and a deduction therefrom, by comparison with the rainfall and temperature records, of the amounts which may be stored in the year of minimum rainfall; (4) the relation which the runoff in the year of minimum precipitation bears to what may be expected in the average year, and, a deduction therefrom of the proper height of flow lines for full capacity development; (5) the areas of the reservoirs themselves, and the losses therefrom by evaporation, which may be reasonably expected; (6) the amount of effective storage which may be gained by the reservoir system, when developed to full capacity;

(7) the amount of water now diverted for the use of the Champlain canal; (8) the amount to be diverted for such use when the enlargement is completed; (9) the amount of water power now in use on the stream and the effect thereon of the present and future diversion; (10) the regimen of the tidal section and the effect thereon of the unregulated freshwater inflow; (11) the effect on the regimen of the tidal section to result from the construction of the system of impounding reservoirs; (12) the proper method of managing such a system of reservoirs in order to secure the best results to the canal, the navigable section and the water power; (13) the cost of the reservoirs; and finally (14) the relation which the actual cost bears to the amount of storage gained; this latter element determining the commercial feasibility of the project. In addition there are a number of subheads which will require consideration in the course of the discussion.

We will now discuss these several heads in detail, premising, however, that, by reason of inability to complete the topographical surveys this year, a portion of the discussion is necessarily tentative and subject to modification in a future report, after the complete data shall have been gathered.

SUBDIVISIONS OF THE WATERSHED AND GENERAL LOCATION AND EXTENT OF RESERVOIR SITES.

On Plates I. and II. we have the various subdivisions of the total drainage area indicated, as well as the general locations for dams.

The Sacandaga river has as we have seen a total drainage area above its mouth at Hadley of 1,040 square miles.

Of this we may control to full capacity in the year of minimum rainfall the following:

The drainage area of Lakes Pleasant and Sacandaga	45	square	miles.
Piseco lake	55	"	"
Arietta flow	40	"	"
Total	140	"	"

Or with the one large reservoir in the Schroon valley we have 1,206 square miles.

The detail of the various locations and the extent of the reservoir sites will be given, so far as we have the information at hand, further on.

POSSIBLE ADDITIONAL STORAGE OF THE SACANDAGA VALLEY.

The foregoing statistics of the drainage areas show that the available storage of the Sacandaga valley is much smaller than that of either of the others, due largely to the absence from this watershed of large lakes and ponds. The valleys are also generally both steep and narrow, thus offering less natural advantages for obtaining large storage at small cost than the other valleys. What is said on this point is, however, quite general, as the time at my disposal has not permitted of as thorough an examination as could be desired.

The topographical surveys, when completed, will largely furnish the required detailed information on this point.

There is also, possibly, an opportunity to make a large reservoir on the Sacandaga by the erection of a dam twenty feet in height at Conklinville, where there is a reach of level river extending twenty-four miles, to Northville. The available storage would be about 4,000,000,000 cubic feet, but inasmuch as there is yet no definite data at hand as to the effect of twenty feet rise on the valley it is considered best on the whole to leave this reservoir for the present out of the account.

It is also possible to construct some reservoirs with very high dams (eighty to one hundred feet or more) in the Sacandaga valley above Northville, but probably at much greater expense per million cubic feet of water stored than for the lower dams of the balance of the valley. In the absence of the definite data, this part of the work is also left untouched at this time.

The estimates, moreover, do not include any of these possible additional reservoirs in the Sacandaga valley.

RAINFALL, MEAN TEMPERATURE AND PHYSICAL CHARACTERISTICS OF THE UPPER HUDSON DRAINAGE AREA.

The rainfall is the source of all the water running off in streams. As a general proposition we may say the greater the rainfall the greater the runoff, although the distribution of the rainfall has so much to do with the amount flowing off that the general statement can be taken as only relatively true. In any case a knowledge of the rainfall of the tributary regions becomes of vast importance in such a study as that now in hand.

From it when properly understood we may predict with considerable certainty the flow of the stream several months in advance.

The entire Upper Hudson area is a region of rugged, granite mountains, with extensive sand areas frequently of considerable depth in the valleys.

Interspersed are numerous lakes and ponds, whose extent and number are shown in a general way on Plates I. and II.

The water falling on the bare sides of the mountains, runs quickly to the valleys, and that portion of it not retained by temporary storage in the ponds and lakes is at once delivered to the streams.

On the sand areas the opposite prevails. Nearly the entire rainfall sinks into the porous ground, and is from thence slowly delivered to the streams.

There are also on the sides of the higher mountains, usually in the spruce forests, extensive growths of what the woodmen call "spruce duff," which is sometimes two or three feet in thickness, and has the power of holding water like a sponge.

It may be considered as assisting somewhat in equalizing the flow of the stream.

The forest itself, by its influence on meteorological conditions, exercises some influence in retarding the runoff.

In a future report, after the completion of the topographical survey over the entire area, it will be possible to give the relative proportions of the original forest, second growth and cleared area. As such information is of great value in connection with the discussion of the influence of the forest on stream flow, that division of our subject will not be touched in this report.

In the meantime it may be stated that the influence of the forest on stream yield is quite material, and incidentally a proposition to utilize the surplus waters of the Upper Hudson by storage leads one to the conclusion that the benefits of such storage may be added to by a rational system of forestry.*

A knowledge of the mean temperature is important, as experience of other streams shows that for a given rainfall, a decrease in the mean temperature is accompanied by an increase in the run-off of streams. In his report on the water power of New Jersey Mr. Vermeule has shown that at mean temperatures of about 50 degrees, an increase of one degree is accompanied by an increase in the loss by evaporation of about five per cent.; or a decrease of one degree by a corresponding decrease in the evaporation. Mr. Vermeule holds that variation in temperature is a more potent cause of variations in stream flow than forests, topography or the other causes usually assigned for such variation.

A considerable amount of information in regard to the temperatures of the Upper Hudson area has been gathered, but lack of time prevents putting it in order for this report.

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* Those interested in the meteorology of forests may find about all the definite information there is in

(1) Report on Forestry, to the Commissioners of Agriculture, by Franklin B. Hough. 1878.

(2) Forest Influences, Bulletin No. 7, of the Forestry Division of the United States Department of Agriculture, 1893. This Bulletin contains discussions of the following:

(*a*) Introduction and Summary of Conclusions, by B. E. Fernow.

(*b*) Review of Forest Meteorological Observations; A study preliminary to the discussion of the relation of forests to climate, by M. W. Harrington.

(*c*) Relation of Forests to Water Supply, by B. E. Fernow.

(*d*) Notes on the Sanitary Significance of Forests, by B. E. Fernow.

(*e*) Determination of the True Amount of Precipitation and its Bearing on Theories of Forest Influences, by Cleveland Abbe.

(*f*) Analysis of Rainfall with Relation to Surface Conditions, by Geo. E. Curtis.

(3) Report on the Forest Conditions of the Rocky Mountains, Bulletin No. 2. Forestry Division, Department of Agriculture, 1889.

(4) Report on Water Supply, Water Power, the Flow of Streams and attendant Phenomena in New Jersey, Vol. III. of the Final Report of the State Geologist of New Jersey. By C. C. Vermeule, 1894.

(5) A large number of references may also be found in the Annual Reports of the Chief of Engineers, for which see indexes to the same. Also see Annual Reports of the Forestry Division, Department of Agriculture.

For the present we may say that taking into account all the various elements of the topography, forest, temperature, and actual rainfall, the net result is a stream not differing in any very important particular from the other streams of the State.

RAINFALL RECORDS OF THE UPPER HUDSON VALLEY.

In order to show the peculiarities and fluctuations of the rainfall of the Hudson river valley for a long series of years, Tables 1 to 5, inclusive, have been prepared. In all these tables the water year is considered as beginning with the month of December of the preceding year. Thus the water year of 1879 extends from December, 1878, to November, 1879, inclusive. The months from December to May constitute what may be termed the storage period. During this time vegetation is inert, the temperature low, with consequent light evaporation; usually from seventy to eighty per cent. of the precipitation of this period runs off in the streams.

June to August, inclusive, constitute the growing period. The temperature is at its highest for the year, vegetation is active. For this period only about twenty per cent. of the rainfall appears in the streams, and some of this is usually the stored ground water of the preceding period.

September to November, inclusive, constitute the replenishing period. The temperature is again relatively low, vegetation inert, and the rainfall goes to replenish the stock of ground water, as depleted during the growing period; or, after the ground again becomes full, appears as direct runoff in the streams.

Table No. 1 is the precipitation at Albany, as kept by the United States Weather Bureau, from 1879 to 1895, inclusive, a period of seventeen years. From it we learn that the mean rainfall of the storage period is 16.71 inches; the highest for that period being 20.73 inches, in 1888; the lowest, 12.58 inches, in 1895.

For the growing period the mean is 11.31 inches, with a range from 15.95 inches, in 1883, to 6.62 inches, in 1886.

For the replenishing period the mean is 9.36 inches, with a range from 15.85 inches in 1890 to 4.97 inches in 1892.

For the entire year the mean of the seventeen-year period is 37.38 inches, with a range from 46.43 inches, in 1888, to 30.39 inches, in 1895.

Table No. 2 is the precipitation at Glens Falls for the same seventeen-year period as table No. 1. This table has been prepared by combining a rainfall record kept by Mr. J. Lapham, and a snowfall record kept by Mr. S. J. Landon, both of Glens Falls. The rainfall has been mostly kept with a Symons gage,* while the depth of snowfall was measured at each precipitation. The snowfall record has been reduced to terms of rainfall, on the assumption that a foot of freshly fallen dry snow is equivalent to one inch of rain. From this table we learn that the mean precipitation of the storage period at Glens Falls is 17.35 inches; the highest 23.76 inches, in 1888; the lowest 13.07 inches, in 1883.

The mean of the growing period is 10.25 inches; the highest, 15.95 inches, in 1893; the lowest, 4.61 inches, in 1880.

For the replenishing period the mean is 8.56 inches; the highest, 12.12 inches, in 1888; the lowest, 5.75 inches, in 1893.

For the entire year the mean is 36.16 inches; the highest year, 45.43 inches, in 1888; the lowest, 28.06 inches, in 1881.

Table No. 3, is the precipitation at Keene Valley, just north of the Upper Hudson drainage area for the same seventeen-year period as is covered by the preceding tables. This station is located directly among the highest mountains of the region, and although the valley is at an elevation of only 1,000 feet above sea level, still the valleys are so narrow, and the high mountains so near, that it is considered probable that this station gives a fair idea of the precipitation of the high mountain region, although it is recognized that due to prevailing direction of rain-bearing air currents, the precipitation may be somewhat greater on the west side of the mountains than it is here on the east. The record has been kept by Mr. O. S. Phelps, of Keene Valley, with the standard instruments of the State survey. The snowfall has been melted after each precipitation and entered as inches of rainfall.*

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* For the first few years the rainfall was measured in an ordinary receiving vessel.

From Table No. 3 we learn that the mean precipitation of the storage period at Keene Valley is 15.35 inches; the highest, 21.89 inches, in 1890; the lowest, 9.83 inches, in 1895.

For the growing period the mean is 10.71 inches; the highest, 17.94 inches, in 1892; the lowest, 7.20 inches, in 1884.

For the replenishing period the mean is 9.05 inches; the highest, 12.47 inches, in 1888; the lowest, 5 inches, in 1887.

The mean of the entire year is 35.11 inches; the highest year being 45.61 inches, in 1890; the lowest, 28.20 inches, in 1881.

These three tables show that what has been found true elsewhere is true here, that the rainfall of the Hudson river area increases somewhat as we go towards the mouth of the river. At New York city it is considerably greater than at Albany.

In order to further exhibit the precipitation of the extreme upper valley and the adjacent regions, Table No. 4 has been prepared from the records of the State Meteorological Bureau.

A considerable portion of the drainage area of the Hudson above Mechanicville lies in the States of Massachusetts and Vermont, and, in order to show the rainfall there, we present Table No. 5, compiled from the records of the New England Meteorological Society, which gives the precipitation at Williamstown and other points, as indicated, in Western Massachusetts and Southern Vermont.

These tables all show with unerring certainty that we may expect, under present conditions of forestration, cultivation, etc., years in which the rainfall of the storage period will not exceed about twelve to fifteen inches over the entire upper Hudson drainage area; locally, as we have seen, it may drop as low as about ten inches for this period.

Our reservoirs for full capacity development will therefore be designed with reference to these deductions from the precipitation record.

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* The first five years of this record was published in Mr. Colvin's Report on the Adirondack and State Land Surveys for 1886, p. 174.

TABLE NO. 4: SHOWING MONTHLY RAINFALL OF THE NORTHERN PLATEAU FROM JUNE, 1889, TO NOVEMBER, 1895, INCLUSIVE.

(In inches.)

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	Mean.
December	....	3.12**	3.01	4.41	2.11	5.75	3.01	3.57
January	....	3.86**	4.82	5.99	2.16	3.48	2.96	3.88
February	....	4.63**	4.91	3.15	4.43	2.87	1.58	3.60
March	....	1.49*	3.70	3.59	1.97	2.26	2.14	2.52
April	....	1.82*	2.46	1.62	3.52	1.81	3.11	2.39
May	....	4.96*	1.79	6.19	5.64	5.20	2.99	4.46
Total	....	19.88	20.69	24.95	19.83	21.37	15.79	20.42
June	5.85**	2.34*	3.42	5.38	3.20	4.40	2.61	3.88
July	4.25**	2.22*	6.06	4.90	3.34	2.89	3.13	3.83
August	2.72**	6.99*	4.01	8.84	6.83	1.44	4.63	5.07
Total	12.82	11.55	13.49	19.12	13.37	8.73	10.37	12.78
September	3.69**	4.58*	1.96	3.41	3.90	4.00	3.42	3.57
October	4.17**	2.98	2.90	2.16	1.96	5.10	2.14	3.06
November	2.21**	3.02*	3.92	4.23	3.12	2.77	4.95	3.46
Total	10.07	10.58	8.78	9.80	8.98	11.87	10.51	10.09
Yearly total	....	42.01	42.96	53.87	42.18	41.37	36.67	43.29

* Keene valley.

** Precipitations at Saranac lake.

From December, 1890, to November, 1896, inclusive, the precipitations are the means of the northern plateau as per Bulletins of State Weather Bureau.

TABLE NO 5: SHOWING MONTHLY RAINFALL OF WESTERN MASSACHUSETTS FROM DECEMBER, 1887, TO NOVEMBER, 1895. FROM THE WILLIAMS COLLEGE RECORD WHEN NOT OTHERWISE STATED.

(In inches.)

Month.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	Mean.
December	4.65*	4.35*	5.60**	3.18†	3.59	5.46	5.94	1.73	4.31
January	2.20*	4.85*	3.41	6.61†	2.68	2.72	2.63	1.76	3.36
February	4.95*	1.16	3.92	3.84†	1.13	3.72	2.50	1.39	2.83
March	7.89	2.30*	4.06	2.89†	1.75	1.39	1.33	1.89	2.94
April	3.70*	0.72	1.46	2.74†	0.40	2.43	1.25	3.50	2.02
May	3.64	1.79	4.68	1.82†	5.43	2.75	3.14	2.10	3.17
Total	27.03	15.17	23.13	21.08	14.98	18.47	16.79	12.37	18.63
June	3.90	5.08	1.72	3.81‡	2.07	2.08	3.64	3.62	3.24
July	1.23	5.81	3.61**	5.43	4.22	1.46	3.43	2.37	3.44
August	4.48	2.94	4.66**	4.48	4.58	5.84	1.06	3.25	3.91
Total	9.61	13.83	9.99	13.72	10.87	9.38	8.13	9.24	10.59
September	6.25*	2.39	6.54**	0.74	1.68	4.46	3.78	2.24	3.51
October	5.50*	2.95	6.89†	1.80	1.57	2.26	4.59	1.74	3.41
November	6.30*	4.20	1.24†	1.80	2.99	1.22	0.85	4.12	2.84
Total	18.05	9.54	14.67	4.34	6.24	7.94	9.22	8.10	9.76
Yearly total	54.69	38.54	47.89	39.14	32.09	35.79	34.14	29.71	38.98

* Rowe, Mass.

** Manchester, Vt.

† Amherst, Mass., Agricultural Experiment Station.

‡ Hoosac Tunnel.

THE ACTUAL RUNOFF OF THE STREAM AS DETERMINED BY EIGHT YEARS' DAILY GAGINGS AT MECHANICVILLE.

The Duncan Company at Mechanicville, formerly the Hudson River Water-Power and Paper Company, began in 1887 a daily gaging of the amount of water passing over their dam. This record has been kept up with one or two exceptions every working day from October 1, of that year, to the present time. A record has also been kept of the number, size and kind of turbine water wheel in use each working day for the same period. The Duncan Company have kindly placed all this material at the disposal of the survey, and having the height of water on the dam and the mean head on the wheels, I have been enabled to compute the mean daily flow of the river for each working day of the eight years and two months from October 1, 1887, to November 30, 1895.

The flow for Sundays and holidays, where no observations were taken, has been assumed as a mean between the preceding Saturday and the following Monday, etc.

The dam is a substantial structure of masonry, with a length of 794 feet between the abutments. The crest is level,* and, from all that can be learned, it appears that the daily observations have been taken with such care, there seems no reason for doubting that this is a fairly accurate exhibit of the daily flow of the stream for the period covered.

Plates III., IV., V. and VI. give this daily flow graphically in comparison with the rainfall and the mean temperature. Explanations as to the rainfall and temperature records used are given in the notes on each diagram. The stream flows are means for each day in cubic feet per second.

The greatest depth on the dam in the eight-year period occurred May 5, 1893, when the gage showed a depth of 7.83 feet and the mean flow for the day was over 53,000 cubic feet per second.

Experience in flows over dams of this length and with this

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* So stated by John R. Kaley, C. E., who was in charge of the construction of this dam.

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* The method of deducing equations (3) and (4) may be found in Mullin's Irrigation Manual, 1890, pp. 11-12, 138-139, and 171-172.

depth is as yet rather limited in this country, and the question was raised as to the best method of computing the discharge for a case like the one under discussion. The East Indian engineers have had, in connection with their large irrigation works, perhaps more experience in this class of work than all others combined, and the formula used by them appears more rational in form than those commonly used in the United States, and after some study its use was decided upon for the present case. As many American engineers may not be familiar with this formula, I will reproduce it here. It takes the following form:

$$Q=\tfrac{2}{3}\ L.\ C.\ \sqrt{2g\ d^3} \qquad (1)$$

in which

Q=the discharge over a thin-edged clear overfall, in cubic feet per second.

L=the length of the dam in lineal feet.

C=a co-efficient depending for its value on d.

g=acceleration of gravity=32.2.

d=depth on crest in lineal feet.

Equation (1) may also take the form.

$$Q=5.35\ L.\ C.\ \sqrt{d^3} \qquad (2)$$

To find C for different values of d we have

$$C=\left(\frac{0.04\ (34.6+d)}{4}\right) \qquad (3)$$

This gives a series of values of C corresponding to d. For instance, for d= 25 feet, C=0.651; for d=0.50 feet, C=0.649, and so on.

For a wide-crested dam the co-efficient is further modified to suit the actual width of the crest. For this we have given the expression,

$$C'=C-\left(\frac{0.025\ C\ (B+1)}{1+d}\right) \qquad (4)$$

in which

B=the width of the crest in lineal feet.

C=the co-efficient for thin-edged weir corresponding to a depth d, as per equation (3), and

C'=the adjusted co-efficient corresponding to a given breadth B and a depth d.*

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* The method of deducing equations (3) and (4) may be found in Mullin's Irrigation Manual, 1890, pp. 11-12, 138-139, and 171-172.

In the case of the Mechanicville dam we have a stone crest seven feet in width and slightly inclined up stream. The effect of the inclination is to reduce the conditions more nearly to those of discharge over a thin-edged weir. The height of the dam is sixteen feet and the width of the river, a short distance above, considerably over 800 feet. With high heads on the dam the velocity of approach while amounting to something will still be small, but in order to simplify the computation it was desirable to neglect velocity of approach. The crest was therefore assumed five feet wide, the velocity of approach neglected and values of C^1 computed on that basis.

Having obtained values of C^1 for $d = 0.25, 0.50, 0.75, 1.00, 1.25, 1.50, 1.75$ feet and so on up to eight feet, the corresponding values of Q were computed and platted at a large scale as a curve, with values of d as abscisses and the corresponding flows as ordinates. From this curve the intermediate values of Q have been quickly and easily read off.

It will be observed that the Indian engineers' formula applies to such computations the principle of the sliding or varying co-efficient, the co-efficient varying both with variations in d as well as B. This is so thoroughly in line with current practice in other departments of hydraulics as to constitute, apparently, a distinct improvement on the ordinary methods.

Table No. 6 exhibits the actual runoff of the stream at Mechanicville by months, from October, 1887, to November, 1895, inclusive, with the monthly runoff given in inches of depth over the entire drainage area in order that it may be readily compared with the rainfall.

Examining Table No. 6 in detail, we learn that the range of the runoff in the storage period from December to May, inclusive, has been, for the eight years, from 22.50 inches in 1892, to 11.68 inches in 1895.

In the replenishing period the range is from 6.81 inches in 1890, a range from 6.87 inches in 1892 to 2.07 inches in 1891.

In the replenishing period the range is from 6.81 inches in 1890, to 1.90 inches in 1891.

TABLE NO. 6: SHOWING THE RUNOFF OF THE HUDSON RIVER AT MECHANICVILLE FROM OCTOBER, 1887, TO NOVEMBER, 1895, INCLUSIVE.

(In inches on the watershed.)

Month.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
December	.....	2.05	2.57	3.39	0.83	2.27	1.03	1.85	1.12
January	.....	1.62	2.81	2.89	2.12	4.83	0.82	1.73	0.99
February	.....	0.89	0.88	1.83	2.70	2.22	1.09	1.12	0.82
March	.....	1.75	2.12	2.85	4.55	2.80	2.11	3.78	1.08
April	.....	5.26	3.39	3.73	4.97	5.35	4.44	2.76	5.91
May	.....	5.49	2.27	4.59	1.42	5.03	5.71	1.94	1.76
Total	.....	17.06	14.04	19.28	16.59	22.50	15.20	13.18	11.68
June	.....	1.22	1.70	1.83	0.79	3.08	1.19	1.76	0.70
July	.....	0.39	1.47	0.50	0.60	2.38	0.65	0.81	0.66
August	.....	0.44	1.09	0.52	0.68	1.41	1.28	0.63	1.00
Total	.....	2.05	4.26	2.85	2.07	6.87	3.12	3.20	2.36
September	.....	0.71	0.49	2.19	0.51	1.10	1.70	0.47	0.65
October	0.61	1.18	0.96	2.36	0.38	0.72	0.99	0.94	0.69
November	1.04	2.64	1.96	2.26	1.01	1.89	0.90	1.58	2.08
Total	.....	4.53	3.41	6.81	1.90	3.71	3.59	2.99	3.42
Yearly total	.....	23.64	21.71	28.56	20.56	33.08	21.90	19.37	17.46

For the entire year the range is from 33.08 inches in 1892, to 17.46 inches in 1895.

A comparison of these actual runoffs with the rainfalls leads to some interesting and pertinent conclusions.

The danger of basing conclusions as to the runoff of a stream on the rainfall record of a single station is illustrated by comparing the runoff for the storage period of 1888, with the several rainfall records covering the same time. We have rainfalls and stream flow as follows:

Albany.	Glens Falls.	Keene Valley.	Western Mass.	Mean of all.	Runoff of stream.
20.73	23.76	14.62	27.03	21.53	17.06

From these figures it appears that during the storage period of 1888, the runoff of the stream was 17.06 inches, while the rainfall at Keene Valley was only 14.62 inches, or 2.44 inches less than the actually observed runoff. Taking, however, into account the precipitation at Albany, Glens Falls, etc., and we find a mean precipitation for the period of 21.53 inches, a figure comparing with the observed runoff, which is found to be eighty per cent. of this mean precipitation.

Again, we will consider the case of the rainfall and runoff of the storage period of 1894, where the observed runoff was 13.18 inches and the rainfall of the Northern Plateau as given by the records of the State Meteorological Bureau was 21.37 inches.

The stations of the Northern Plateau reporting for the storage period of 1894 were Lyon Mountain, Clinton county; Saranac Lake, in Franklin county; Gloversville, Fulton county; Constableville, Lowville, Number Four and Turin, all in Lewis county; West Chazy, Clinton county; Au Sable Forks and Keene Valley, in Essex county.

For December, 1893, the precipitation at Lowville, Number Four and Turin, all to the west of the Upper Hudson area, was 5.81, 5.92 and 6.93 inches respectively, while West Chazy, Keene Valley and Saranac Lake showed 3.46, 3.92 and 4.27 inches respectively.

For January, 1894, we have a mean of 3.73 inches at Lowville, Number Four and Turin; and at West Chazy, Saranac Lake and

Keene Valley a mean of 2.92 inches. For February, 3.55 inches at the former and 1.68 inches at the latter three places; March, 2.63 inches and 1.57 inches; April, 2.24 inches and 0.87 inches; May, 4.84 inches and 4.54 inches.

From this statement it is seen that the precipitation of the western part of the Northern Plateau was much greater during all the months of the storage period of 1894 than was that of the stations nearer the high Adirondack mountains. Hence, the mean of that period as appearing in the records of the State Meteorological Bureau will be too high for our case. Taking the means of the three stations at West Chazy, Saranac Lake and Keene Valley, we have for the whole period from December, 1893, to May, 1894, inclusive, a total of 15.46 inches. Tabulated we have.

Mean of West Chazy, Saranac Lake and Keene Valley.	Glens Falls.	Albany.	Western Mass	Mean of all.	Runoff of stream.
15.46	16.50	15.20	16.79	15.99	13.18

The mean of all the precipitations really applying is found to be 15.99 inches, a result which agrees with the observed runoff of 13.18 inches for the period. We also find that 13.18 is 82 per cent. of 15.99.

We will now compare the runoffs of the Hudson with those of some other large streams which have been studied in the same way.

The first is the Passaic river in New Jersey, with a drainage area of 822 square miles. Table No. 7 gives the results for several of the years included in the Hudson record.*

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* From Mr. Vermeule's Report on Water Supply and Water Power of New Jersey.

TABLE NO. 7: SHOWING THE RUNOFF OF THE PASSAIC RIVER IN COMPARISON WITH THE RAINFALL FOR A SERIES OF YEARS.

(In inches on the watershed.)

Month.	1888.		1889.		1890.		1891.		1892.		1893.	
	Rainfall.	Runoff.	Rainfall.	Runoff.	Rainfall.	Runoff.	Rainfall.	Runoff.	Rainfall.	Runoff.	Rainfall.	Runoff.
Dec. ...	5.72	2.32	4.33	4.51	2.14	4.40	4.17	1.98	4.73	2.04	1.47	1.18
Jan. ...	5.77	4.61	6.04	5.75	2.69	2.01	7.52	5.92	5.38	5.34	3.87	3.86
Feb. ...	4.41	3.90	2.41	2.28	4.59	3.24	4.55	5.41	1.35	1.55	6.35	5.65
March .	6.68	4.97	3.22	2.19	6.03	3.30	4.24	5.30	4.19	2.66	3.43	6.95
April ..	3.97	6.13	6.34	3.41	2.58	2.99	2.30	2.49	1.69	1.43	4.59	4.88
May ...	6.09	0.69	2.85	2.85	4.39	2.74	2.80	0.94	4.92	1.42	5.15	4.83
Total	32.64	22.62	25.19	20.99	22.42	18.68	25.58	22.04	22.26	14.44	24.86	27.40
June ..	2.80	0.38	3.43	1.65	4.55	1.78	1.86	0.44	4.68	1.20	3.60	2.32
July ...	1.98	0.36	14.49	2.31	6.14	1.47	5.16	0.31	3.27	0.52	2.25	0.71
Aug. ..	7.60	1.00	4.49	4.14	4.96	1.04	5.72	0.83	4.39	0.53	7.26	1.05
Total	12.38	1.74	22.41	8.10	15.65	4.29	12.74	1.58	12.34	2.25	13.11	4.08
Sept. ..	8.06	4.19	10.06	3.90	3.73	1.52	2.25	0.64	2.17	0.40	2.92	0.58
Oct. ...	4.53	2.65	3.06	2.15	5.20	2.49	2.50	0.31	0.72	0.25	4.59	1.25
Nov. ..	4.09	3.00	10.16	6.29	0.75	1.37	2.96	0.63	6.84	1.38	3.65	1.30
Total	16.68	9.84	23.28	12.34	9.68	5.38	7.71	1.58	9.73	2.03	11.16	3.13
Yearly Total	61.70	34.20	70.88	41.43	47.75	28.35	46.03	25.20	44.33	18.72	49.13	34.61

We have here the case of a stream issuing from an area of much higher rainfall than that of the Upper Hudson; and while the runoffs are generally larger we have still the year 1892, where with a rainfall of 44.33 inches the runoff was only 18.72 inches or (18.72 — 17.46) = 1.26 inches more than the runoff of the Hudson for the year 1895, in which year the rainfalls of the Hudson area were:

Albany, 30.39; Glens Falls, 37.20; and Keene Valley, 36.18 inches.

Other useful comparisons can be made from Table No. 7, which it is unnecessary to refer to here.

Again taking the Connecticut river, which was gaged by the United States government engineers from 1871 to 1878, we find that during the water year of 1877, with a rainfall of 42.76 inches, the runoff was 20.92 inches. The drainage area of the Connecticut above the point of gaging is 10,234 square miles.

The Croton river with a drainage area of 353 square miles, and a rainfall of 44.63 inches, gave, in 1870, a runoff of 19.79 inches; in 1872, 40.74 inches rainfall yielded 17.42 inches of stream flow; in 1880, 38.52 inches of rainfall gave only 14.54 inches in the stream. Following 1880, in 1881, 45.72 inches of rainfall yielded only 17.44 inches in the stream.

The differences in yield of the stream for given rainfalls which we observe are due mostly to the differences in temperature from year to year and the consequent fluctuations in the evaporation. This division of the subject is necessarily reserved until a future report.

In any case we may draw from the foregoing data the safe conclusion that we can not hope to store on the Hudson river, during the storage period of the year of minimum rainfall, more than ten to twelve inches over the tributary watershed.

THE RELATION OF THE MINIMUM RUNOFF TO THE HEIGHT OF FLOW LINES FOR FULL CAPACITY DEVELOPMENT.

In discussing this division of our subject we will first consider the extent and significance of the several low water periods which have occurred in the eight years covered by the Mechanicville gagings. Referring to the diagrams, Plates III. to VI., inclusive, we locate a series of periods when the river was below about 4,500 cubic feet per second at Mechanicville for considerable time, as follows, one or two short periods being neglected:

In 1888, from June 12 to September 20, total, 101 days; 1889, August 12 to October 31, a total of 81 days; 1890, June 23, to

August 22, a total of 61 days; 1891, May 28 to November 17, a total of 174 days; 1892, July 20 to August 25, and September 4 to November 4, a total in the two periods of 68 days; 1893, December 2 (1892) to February 6, 1893, a total of 67 days; also in 1893, June 12 to August 24, and September 24 to November 29, a total for the two of 100 days; 1894, June 12 to October 11, a total of 122 days; and in 1895, May 25 to November 9, a total of 169 days. The rise of two days in August is not deducted from this latter period.

We will now compute the amount of water required to hold the flow at 4,500 cubic feet per second at Mechanicville during some of the more extended of these dry periods, first, however, remarking that 4,500 cubic feet per second flow has been fixed upon as the proper minimum at which the river should be maintained, for reasons connected with the improvement in the navigation of the tidal section, which will be discussed further on.

The first low water period was from June 12 to September 19, 1888, when we had:

	Cubic feet per second.
Mean flow, June 12 to 30	4,007
Mean flow, July	1,537
Mean flow, August	1,725
Mean flow, September 1 to 19	2,163
Mean for 100 days	2,162

Deducting 2,162 from 4,500, we have 2,338 as the number of cubic feet per second to be added as a mean for the 100 day low water period, in order to maintain, at Mechanicville, a flow of 4,500 cubic feet per second.

Taking the actual flows at other points as proportional to the tributary drainage areas, we compute the following as the mean flows at Glens Falls and Troy for the same time:

	Glens Falls, cu. ft. per sec.	Troy, cu. ft. per sec.
June 12 to 30	2,493	7,265
July	957	2,786
August	1,073	3,128
September 1 to 19	1,345	3,922
Means	1,345	3,959

Adding to the foregoing means of the actual flows at Glens Falls and Troy the 2,338 cubic feet per second required to hold the river at 4,500 cubic feet at Mechanicville, and we obtain a mean flow at Glens Falls of 3,683 cubic feet per second, and of 6,297 cubic feet at Troy.

The total quantity to be stored in order to tide over this 100-day period of low water would be then (86,400 × 100 × 2,338) = 20,200,000,000 cubic feet.

Passing by the shorter low water periods of 1889 and 1890, we will now consider that from May 28 to November 17, 1891, a total of 174 days. Taking the flows in every case, in cubic feet per second, we have:

	Mechanicville.	Glens Falls.	Troy.
May 28 to 31	4,167	3,263	7,555
June	3,200	1,990	5,802
July	2,337	1,454	4,237
August	2,666	1,658	4,833
September	2,040	1,269	3,699
October	1,472	909	2,651
November 1 to 17	1,664	1,035	3,017
Means	2,313	1,440	4,197

In order to hold the flow at a minimum of 4,500 cubic feet per second, at Mechanicville, for the whole period, we would require the following mean quantities in cubic feet per second each month:

May 28 to 31	333
June	1,300
July	2,163
August	1,834
September	2,460
October	3,028
November 1 to 17	2,836
Mean	2,187

Adding these latter quantities to the foregoing and we have the following regulated flows at Glens Falls and Troy.

	Glens Falls.	Troy.
May 28 to 31	3,596	7,888
June	3,290	7,102
July	3,617	6,400
August	3,492	6,667
September	3,729	6,159
October	3,937	5,679
November 1 to 17	3,871	5,853
Means	3,627	6,384

The total quantity to be let out of the reservoirs in order to produce this result would be roundly, 33,000,000,000 cubic feet.

The foregoing computation leads also to the conclusion that for this particular low water period the mean flow at Glens Falls would have been increased from 1,440 to 3,627 cubic feet per second. At Troy the increase would have been from 4,197 to 6,384 cubic feet per second.

The low water periods of 1892, 1893 and 1894, were not seriously extended and we may pass to that from May 25 to November 9, 1895, a period of 169 days.

Working in cubic feet per second as before, we have the following unregulated flows:

	Mechanicville.	Glens Falls.	Troy.
May 25 to 31	4,000	2,488	7,252
June	2,816	1,752	5,106
July	2,559	1,592	4,640
August	3,901	2,426	7,073
September	2,629	1,635	4,766
October	2,631	1,636	4,770
November 1 to 9	3,025	1,881	5,484
Means	2,961	1,842	5,368

The quantities to be added each month in cubic feet per second in order to maintain 4,500 cubic feet per second at Mechanicville, are:

May 25 to 31	500
June	1,684
July	1,941
August	599
September	1,871
October	1,869
November 1 to 9	1,475
	1,539

We have, then, regulated flows at Glens Falls and Troy, as follows:

	Glens Falls.	Troy.
May 25 to 31	2,988	7,752
June	3,436	6,790
July	3,533	6,581
August	3,025	7,672
September	3,506	6,637
October	3,505	6,639
November 1 to 9	3,356	6,959
Means	3,381	6,907

The total quantity to be let out of the reservoirs in order to maintain this flow would be roundly, 23,000,000,000 cubic feet.

THE FREQUENCY OF EXTREME LOW WATER PERIODS.

We may conclude from these analyses of the low water period, that, so far as our present knowledge of the river goes, the low water of 1891 was the longest continued and most severe of any of which we have knowledge. We are unable to say, however, that this was the longest period that will ever occur, although it may be apparently safely concluded that a more severe dry weather period than that of 1891 will not occur more than two or possibly three times in a century; although dry periods as severe as that of 1891 will certainly frequently occur. The reasons for this conclusion are briefly indicated by the following:

Referring to Table No. 6, it is learned that 1891, although the year of minimum low water of the eight-year series, was not the year of minimum runoff. For that year the runoff of the storage period was 16.59 inches, and the total of the year 20.56 inches. In 1895 we have 11.68 inches for the storage period and 17.46 inches for the year.

THE INFLUENCE OF THE MAY RAINFALL.

Studying the runoff of the Hudson in comparison with the rainfall records and the runoffs and rainfall records of other streams, and it appears that the permanency of flow during the summer and fall months depends very largely upon the rainfall of the month of May. If the rainfall of May is large enough to insure the beginning of the growing period with full ground water we may expect the stream to keep up during the entire season without, of course, the rainfall of the growing and replenishing periods should be abnormally small, when we may expect low water at the latter end. If, however, the May rainfall is so small that the stored ground water of the previous months is drawn upon, to some extent, to maintain stream flow during that month, then we are certain, even with large rainfalls in the growing and replenishing periods, to have more or less low water from May to October or November. As regards the year 1891, we may note the following:

The total precipitation of the storage period of that year was 17.72 inches, an amount sufficient, when properly distributed, to maintain a steady flow for the balance of the year. The May rainfall was 1.69 inches at Albany, 2.25 inches at Glens Falls, 1.80 inches at Keene Valley, 1.82 inches in Western Massachusetts, and 1.79 inches for the mean of the whole Northern Plateau as given by the records of the State Meteorological Bureau. The mean of May for the seventeen-year period shown in Table No. 1, is 3.28 inches; at Glens Falls the mean, as per Table No. 2, is 3.10; and at Keene Valley, as per Table No. 3, it is 3.05. The May rainfall of 1891 was therefore only a little over one-half of the normal.

Again we may consider the year 1895. Here the rainfall of the whole storage period was quite low, the figures being, 12.58 inches at Albany, 17.0 inches at Glens Falls, 9.83 inches at Keene Valley, 12.37 inches in Western Massachusetts, and 15.79 inches for the whole Northern Plateau. The month of May shows at Albany 1.72 inches, Glens Falls 1.64 inches, Keene Valley 2.60 inches, Western Massachusetts 2.10 inches, and for the Northern Plateau 2.99 inches. West Chazy, Saranac Lake and Turin, however, showed a May precipitation of 3.54, 4.34 and 3.32 inches, respectively. The runoff for May was 1.76 inches. We may conclude then that while the total precipitation of the storage period of 1895 was rather low, still, the May rainfall was on the whole enough to insure nearly full ground water on June 1. All of which lessened as we have seen the severity of the low water of the summer of 1895.

Studying the rainfall records further, we see that in 1879 the rainfall of May was 0.89 inches at Albany, 0.50 inches at Glens Falls, and 0.82 inches at Keene Valley. Taking into account the rainfall of the growing season of 1879, it appears probable that there was more severe low water in that year than in 1891. The year 1887 may also have been one of low water, from the indication of the rainfall records. There is no likelihood, however, that any year covered by Tables Nos. 1, 2 and 3, except 1879, was lower than 1891.

It is clear from the preceding analyses, if one has at hand a reliable precipitation record covering a long series of years, and also a record of stream flow for the same years, that certain general principles governing stream flow are easily arrived at, which enable one to predict on June 1, what the summer flow of a stream will be with considerable certainty.

A SERIES OF GAGINGS OF THE HUDSON RIVER AT SEVERAL POINTS.

In order to secure the data of stream flow for the Hudson river more thoroughly, arrangements have been made, not only to continue the Mechanicville gagings, but also to have a similar series made at Troy, Fort Edward, Sandy Hill and Hadley, on the main river; at Conklinville, on the Sacandaga river, and at Warrensburg, on the Schroon. The mill superintendents at these several places have kindly undertaken to make the necessary daily records without expense to the State. The small expense of furnishing and setting the gages and the expense of record blanks has been borne by this survey.

With these records kept up for several years, we will then be able to predict on June 1, for months ahead, about what the flow of the stream will be.

LOW WATER OF THE HUDSON RIVER COMPARED WITH THAT OF OTHER STREAMS.

First as to extreme low water. Referring to the daily gagings at Mechanicville it is learned that from August 14, 1890, to August 19, the mean flow was 1,080 cubic feet per second. Also from October 2, 1891, to October 6, the mean flow, at the same place, was again 1,080 cubic feet per second.

For 4,500 square miles drainage area this gives 0.24 cubic feet per second per square mile.

The Merrimack river, with a drainage area of 4,599 square miles, has given a minimum flow of 0.31 cubic feet per second per square mile.

The Connecticut, with a drainage area of 10,234 square miles, has given a minimum flow of 0.31 cubic feet per second per square mile.

It appears reasonable to conclude therefore that 0.24 cubic feet per second per square mile is the approximate mean minimum flow of the Hudson.*

Second, as to the low water of long-continued periods. Referring to Table No. 6, it is learned that from June to November, 1891, inclusive, the total flow of the Hudson was 3.97 inches on the watershed.

From Mr. Vermeule's report on the Water Supply and Water-Power of New Jersey, it is learned that from June to November, 1891, inclusive, the total flow of the Passaic river was only 3.16 inches on the whole watershed.

Again Table No. 6 shows that from July to October, 1894, inclusive, the flow of the Hudson was 2.85 inches on the whole watershed.

For July to October, 1881, inclusive, the flow of the Passaic river was only 1.17 inches on the whole watershed. Including the month of November the flow of the Passaic, for the five months of 1881 from July to November, was only 1.74 inches on the watershed.

Other examples could be cited, but the foregoing are sufficient to show how the Hudson, so far as our definite knowledge of its flow goes, compares with other streams in the matter of minimum flow.

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* These figures, we may note, do not include the water diverted for the use of the Champlain canal, which amounts, in different months, to from 200 to 264 cubic feet per second. We really have, therefore, about 0.29 cubic feet per second per square mile as the observed minimum flow.

TABLE NO. 8: SHOWING THE RUNOFF OF THE HUDSON RIVER AT MECHANICVILLE FROM OCTOBER, 1887, TO NOVEMBER, 1895, INCLUSIVE.

(In cubic feet per second.)

Month.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
December	.....	8,018	10,014	13,226	3,244	8,577	4,031	7,217	4,367
January	.....	6.367	10,983	11,272	8,284	18,357	3,192	6,757	3,876
February	.....	3,714	3,790	7,913	11,664	9,263	4,805	4,836	3,543
March	.....	6,845	8,280	11,129	17,736	10,929	8,250	14,738	4,204
April	.....	21,200	13,690	15,053	20,021	21,554	17,889	11,135	23,822
May	.....	21,420	8,871	17,931	5,533	19,622	22,285	7,566	6,850
Mean	.....	11,289	9,337	12,821	11,021	14,831	10,114	8,759	7,759
June	.....	4,917	6,869	7,392	3,200	12,395	4,801	7,097	2,816
July	.....	1,537	5,727	1,950	2.337	9,287	2,521	3,168	2,559
August	.....	1,725	4,272	2,019	2,666	5,485	5,005	2,456	3,901
Mean	.....	2,703	5,718	3,748	2,957	9,019	4,102	4,209	3,095
September	.....	2,851	1,963	8,844	2,040	4,448	6,870	1,889	2,629
October	2,365	4,608	3,740	9,215	1,472	2,819	3,865	3,649	2.631
November	4,190	10,642	7,888	9,121	4,088	7,604	3,639	6,379	8,421
Mean	.....	6,018	4.522	9,061	2,521	4,934	4,781	3,969	4,539
Yearly mean	.....	7,820	7,197	9,597	6,867	10,909	7,271	6,418	5,780

Table No. 8 gives the mean monthly flows in cubic feet per second at Mechanicville. These quantities are the same as those of Table No. 6, except that in Table No. 6, the flows are expressed as inches on the drainage area in order to compare readily with the rainfall, while in Table No. 8 they are in cubic feet per second, for convenience of computation of river regulation, etc.

The conclusion of this division of our subject is, that taking into account past experience, as indicated by the eight-year record at Mechanicville, as well as the indications of the rainfall record for the seventeen-year period of Tables 1, 2 and 3, we may assume a necessary storage of at least 33,000,000,000 cubic feet in order to maintain 4,500 cubic feet per second in the stream at Mechanicville in the year of minimum dry weather flow.

There are also certain necessary additions to this quantity which we will discuss in detail further on.

It will be noticed that the preceding discussion has been made without regard to the losses from evaporation, etc., in the stream. If the additional flow is made such losses will be small over and above what actually exists with the stream in its present condition, for the reason that aside from reservoir surfaces the additional exposed area will be small. For the reservoirs the proper allowance will be made in the discussion of that head.

Let us now see whether a storage requirement of 33,000,000,000 cubic feet to maintain the river flow will demand the development of the available storage to its full capacity.

Referring to page 95 we learn that, if we decide upon the series of small reservoirs in the Schroon valley the total controllable area is 1,183 square miles, or 1,206 square miles with the one large reservoir in that valley.

Using for the present twelve inches as the possible collection of the storage period in the minimum year, and we obtain for 1,183 square miles a total of 32,980,000,000 cubic feet.

For 1,206 square miles the total will be 33,620,000,000 cubic feet.

THE HADLEY RESERVOIR.

We learn, then, that the area susceptible of full control is none too large for an assumed flow of 4,500 cubic feet per second at Mechanicville. There is, however, an opportunity to construct on the main Hudson, at Hadley, just above the mouth of the Sacandaga, a reservoir of say 4,000,000,000 cubic feet capacity, which would give with twelve inches collection a possible maximum storage of 37,500,000,000 cubic feet. We have also seen on page

96 that, if needed, additional reservoirs can be made in the Sacandaga valley. We have, therefore, some leeway for the losses of evaporation from the reservoir surface and other demands for water to be referred to further on.

The natural conditions for constructing a reservoir at Hadley can hardly be excelled. The river has a granitic rock bottom with precipitous banks forty feet in height, and about 100 feet apart. The material for a permanent stone dam exists on the ground, with an opportunity to construct a wasteway over natural rock at one side at small expense. The location of the proposed dam above Hadley bridge is shown by the photograph, Plate A.

Inasmuch as all the storage, except that of the Sacandaga area must pass through this reservoir, its construction would simplify the management of the system very greatly. In the summer season so long as there was any storage above to be drawn upon, this reservoir would be kept nearly full and just the right quantity drawn out from day to day to keep the river at the assumed flow of 4,500 cubic feet per second at Mechanicville.

In the fall, however, this reservoir could be drawn down, and when necessary, filled and emptied two or three times during the winter. How this could be accomplished is made clear from the following:

The tributary area above Hadley, not included in the proposed reservoirs of either the Upper Hudson or Schroon valley systems is 627 square miles, which, on the assumptions made, is capable of yielding, in the minimum year, a storage of 17,500,000,000 cubic feet. The Hadley reservoir would have a capacity of from 4,000,000,000 to 4,500,000,000 cubic feet,* leaving the balance of about 11,000,000,000 cubic feet to flow away unregulated, except so far as management of the Hadley reservoir or the lines indicated in the foregoing might permit of its utilization.

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* This is a general estimate subject to modification later on after the completion of the surveys.

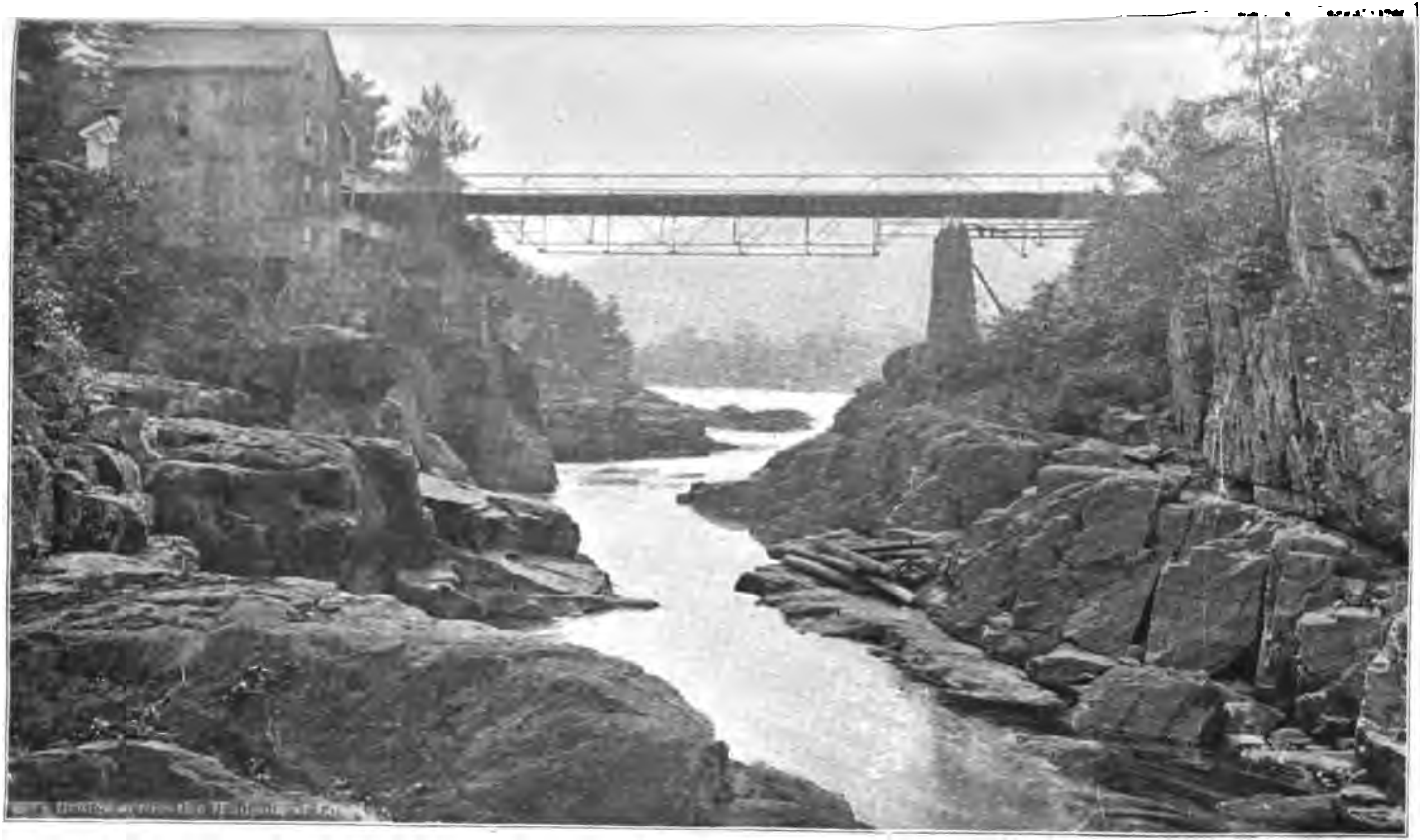

PLATE A.—SITE OF THE PROPOSED HADLEY DAM.

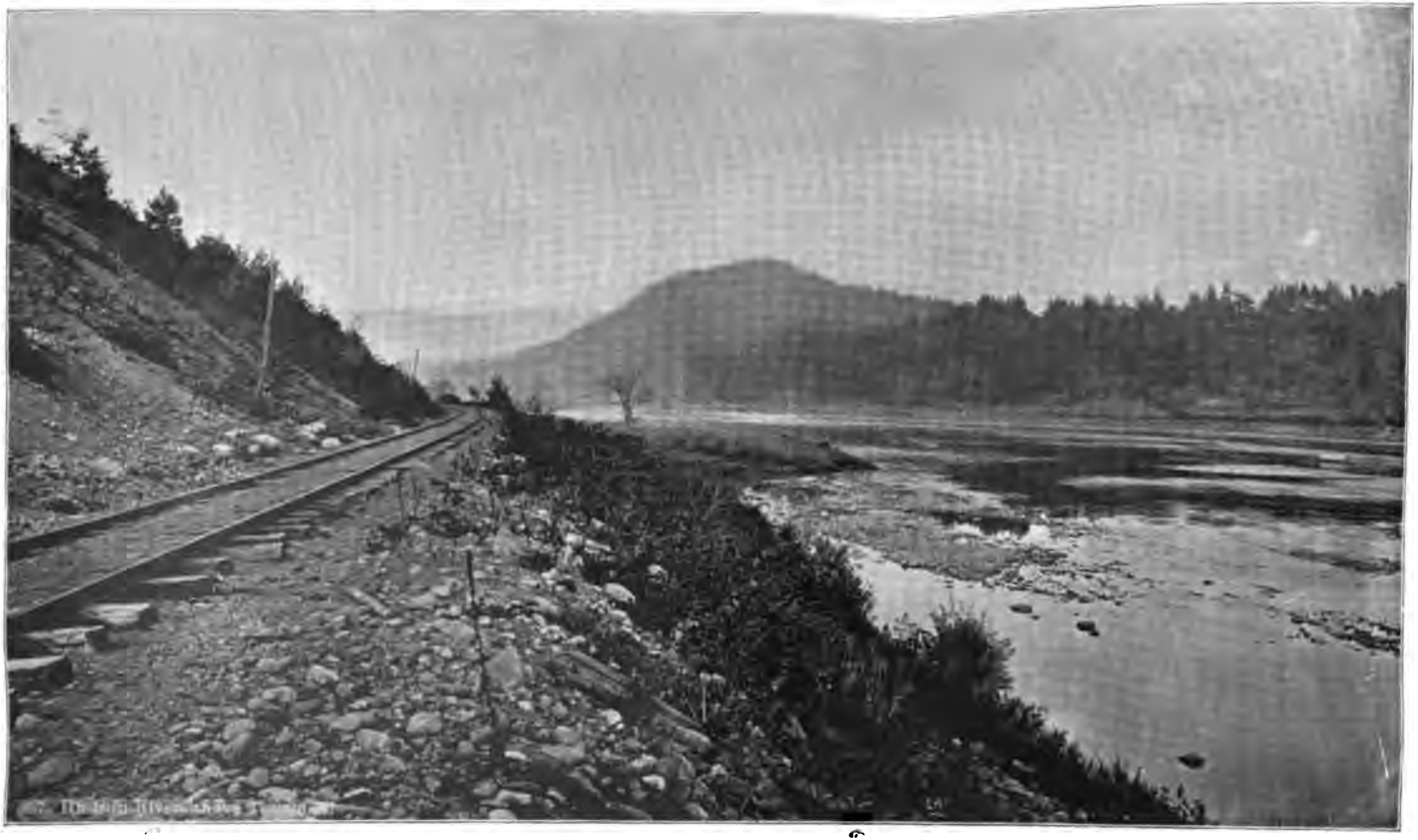

Plate B.—View on Upper Hudson, Showing Location of Adirondack Railway.

THE ADIRONDACK RAILWAY LOCATION.

As an apparent objection to the Hadley reservoir it may be mentioned that its construction would necessitate the relocation of several miles of the Adirondack Railway which now follows the windings of the river not far above high-water mark. On this head it may be remarked that the original location of this railway was an error of judgment, difficult to account for on any other supposition than that the company constructing it had no really clear conception of just what the road is for. In 1870-72, when this road was built, the region penetrated was, as it is to-day, entirely undeveloped, and no railway could hope to be successful there unless it in some way could give the tributary territory an *impetus* towards the development of business for the road.

The Adirondack region has been reputed as possessing considerable mineral wealth, but undoubtedly the most valuable mineral there is water when used to supply power. From just above Thurman to North River village, in a distance of twenty-five miles, the river has a rise of 450 feet. Throughout this whole extent the channel is mostly narrow, with rock bottom either actually showing, or just below the bed. Granitic rock, good enough for permanent dams exists on every hand. For the best development, these dams should be built from twenty-five to thirty feet in height. The judgment of the present writer is, therefore, that, if the Adirondack company had possessed any just appreciation of the possibilities of this region for cheap manufacturing by water power, there would have been at this time a string of large establishments on this section, and the railway, instead of still being a dead weight on the hands of the company operating it, would have long since become a paying property, and the Upper Hudson valley the home of an industrious and thriving manufacturing population.

Again, it is stated to be matter of history that the location of this railway as originally made, was far enough up the side of the valley to leave the river clear for such a development as we are now discussing. Unfortunately, the economy-of-the-moment view prevailed, and, with slight exception the whole line from Stony Creek station to North Creek, a distance of about thirty miles, was finally laid near the water's edge. The photograph, Plate B, illustrates this location saliently. The approximate location of the railway grade in reference to the bed of the river is also shown on Plate VII.

WATER POWER AT THE HADLEY DAM.

By reason of its situation on the main river, this reservoir would naturally be kept full in the years of average rainfall, and only drawn down in the years of deficient rainfall. It is clear, from what has preceded, that there might be periods of several years when this reservoir would always be full. At a depth of twenty feet the storage at Hadley would be quite small, the volume being mostly above the twenty-foot line. We may arrange, then, to never draw this reservoir lower than twenty feet, always leaving that depth as the minimum head to be used for water power development. We have, therefore, an absolutely permanent water power of, say, 1,400 cubic feet per second on twenty feet head, and a nearly permanent water power in addition of at least 1,400 cubic feet per second on heads ranging from twenty to forty feet. Again, 1,400 cubic feet per second is the minimum figure; for the greater part of the year the flow would be greater than this. But 1,400 cubic feet per second on twenty feet head gives 3,146 gross horse power, which at the price of $10.00 per gross horse power — as we shall see further on, this is a reasonable price — would yield an annual income of $31,460.

Again, we would have nearly a permanent power most of the time with somewhat more water and with heads up to forty feet. Such a power has its value for a business like pulp grinding, where it is not necessary to operate continuously. The second water power of this dam may, therefore, be taken at not less than $18,540 more, or, the total yearly value of the water power created by the Hadley reservoir — and which could be used with-

out prejudice to the other interests — would amount to $50,000, which sum capitalized at five per cent. represents $1,000,000.

Further, if it should appear when the surveys are completed, that a similar reservoir is desirable on the Sacandaga river at Conklinville, it could be treated in the same way. The smaller tributary area here and less height of dam would make, however, less power development than at Hadley. Without going into the detail now, we may assume the capitalization of $500,000. We have then a total capitalization of the value of the water power created at these two reservoirs of $1,500,000.

In order to show the longitudinal extent of the Hadley reservoir, as well as the water power possibilities of the stream from Thurman to North River village, and also between Glens Falls and Palmers Falls, I have prepared a profile of the river from the Feeder dam at Glens Falls to North River as delineated on Plate VII. The several questions here referred to are shown so clearly thereon as to require no further discussion at this time.

CONSIDERATIONS GOVERNING LOCATION OF FLOW LINE.

Returning to the question of proper flow line, it may be noted that thus far the discussion has proceeded on the tacit assumption that full capacity development should be based substantially upon the water year of minimum stream flow, although a very cursory examination of Tables 1, 2, 3, 4 and 5, and Tables 6 and 8, shows that much greater yields can be expected in the average year; the question may be asked, then why not make the reservoirs somewhat larger than merely sufficient for the wants of the year of minimum flow, thereby carrying some water over from one year to another, and thus more nearly attaining an absolute regulation of the river — not for a single year but for a series of years. On this point it may be stated that experience with other large reservoir systems is against other than a moderate development on this line. As will be shown further on, such a system of reservoirs is not in any degree an experiment, similar ones have been constructed elsewhere and it has been found repeatedly that however high the flow line the reservoirs are always nearly empty at the beginning of the storage period of the minimum year In practice it is found that the rainfall, and consequently the stream flow, move in cycles of about seventeen years' duration,* during which period there may be several successive years of flow, all above the average. The demands increase during the years of plenty, until the parties in charge apparently forget there will ever be a deficiency. For instance, on again referring to Tables 1, 2 and 3, and Tables 6 and 8, it is seen that with the exception of 1889, the yield of the storage period in every year from 1888 to 1893, inclusive, was great enough to furnish more than twelve inches storage; even in 1889 and 1894 we could go a little higher than the twelve inches.

While it is allowable, therefore, to go somewhat higher than the flow of the minimum year, there should always be substantial reasons for such procedure.

The best practice is to locate the flow line with reference to about the minimum yield, or only an inch or two above it, thus forcing an economy in the use of water from the beginning. By proceeding in this way we may provide for carrying over moderate quantities of water from the latter end of the year more effectually than in any other way.

WATER FOR THE TRIBUTARY STREAMS DURING THE STORAGE PERIOD.

Moreover, we must remember that the stream is entitled to some water even in the storage period, which must go out of the reservoirs whenever the tributary area below the dams fails to furnish this definite quantity, whatever it may be. It is necessary to decide, therefore, on some mean flow of the stream below which it is never allowed to fall. This is done in the interest of the fisheries, etc. For this purpose 0.5 inches per month is taken as the minimum allowance. In cubic feet, this amounts to 0.45 cubic feet per second per square mile for a month of thirty days. But it is not intended to state that the entire river will ever be as low as this (0.45 cubic feet per second per square mile would yield 2,025 cubic feet per second at Mechanicville), but only those tributary streams on which the storage reservoirs are located. With 0.45 cubic feet per second, per square mile, always flowing away from the controlled drainage area, the natural flow of the unregulated portion will usually contribute an additional amount sufficient to keep the river even during the storage period up to nearly the assumed 4,500 cubic feet at Mechanicville. Or in case of extreme low water in winter, the Hadley reservoir may be relied upon to assist in the manner already pointed out.

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* This is of course a very general statement. The writer does not wish to commit himself to the proposition that meteorological phenomena move in cycles of determinate periods.

On the basis of 12 to 14 inches available storage we may have then, with at least 0.5 inches per month always going to the stream, a possible total requirement for the year of as much as 15 to 18 inches.

Referring to Table No. 6, we learn that the total flow for 1895 was only 17.46 inches, or in that year we would have been short on the foregoing basis possibly 0.54 inches. Any such shortage would have been necessarily carried over from the year 1894, when in the month of November there was a runoff of 1.58 inches. Allowing at least 0.50 inches to the stream we would have from the November rainfall alone 1.08 inches remaining in the reservoirs to be carried over to 1895.

It may be also again pointed out that the Hadley reservoir would be specially convenient for assisting such an adjustment as this.

RELATION OF THE MINIMUM FLOW OF LARGE DRAINAGE AREAS TO THAT OF SMALL AREAS.

Again, a minimum of 0.45 cubic feet per second per square mile of drainage is a liberal allowance for the tributary streams. The general principle is, that, in their natural condition the minimum flows from small drainage areas are smaller than from large ones. We have seen that even at Mechanicville where the tributary area is 4,500 square miles, the stream has at times, for short periods, run as low as 0.29 cubic feet per second per square mile. In view then of the general principle just announced, we may conclude that the small area will, on occasion, yield much less than this figure. By way of comparison let us note the minimum yields of a number of other small areas for which accurate results are at hand:

(1.) The Sudbury river in Massachusetts, with a drainage area of 78 square miles, has shown a minimum flow of 0.036 cubic feet per second per square mile.

(2.) The West branch of the Croton river with a drainage area of 20 square miles, has shown a minimum flow of 0.020 cubic feet per second per square mile.

(3.) The entire Croton river with a drainage area of 339 square miles has shown a minimum flow of 0.15 cubic feet per second per square mile.

We have in the Croton river and the West branch a case where the minimum flow of the main river is seven and one-half times the flow of the branch.

(4.) The Paulinskill river in New Jersey, with a drainage area of 126 square miles, has shown a minimum flow of 0.13 cubic feet per second per square mile.

(5.) The Tohickon creek, in Pennsylvania, with a drainage area of 102 square miles, has shown a minimum flow of 0.001 cubic feet per second per square mile.

(6.) The Neshaminy creek in Pennsylvania, with a drainage area of 139 square miles, has shown a minimum flow of 0.009 cubic feet per second per square mile.

(7.) The Perkiomen creek in Pennsylvania, with a drainage area of 152 square miles, has shown a minimum flow of 0.05 cubic feet per second per square mile.

A large number of other similar cases may be cited, but the foregoing are sufficient to show the 0.45 cubic feet per second as

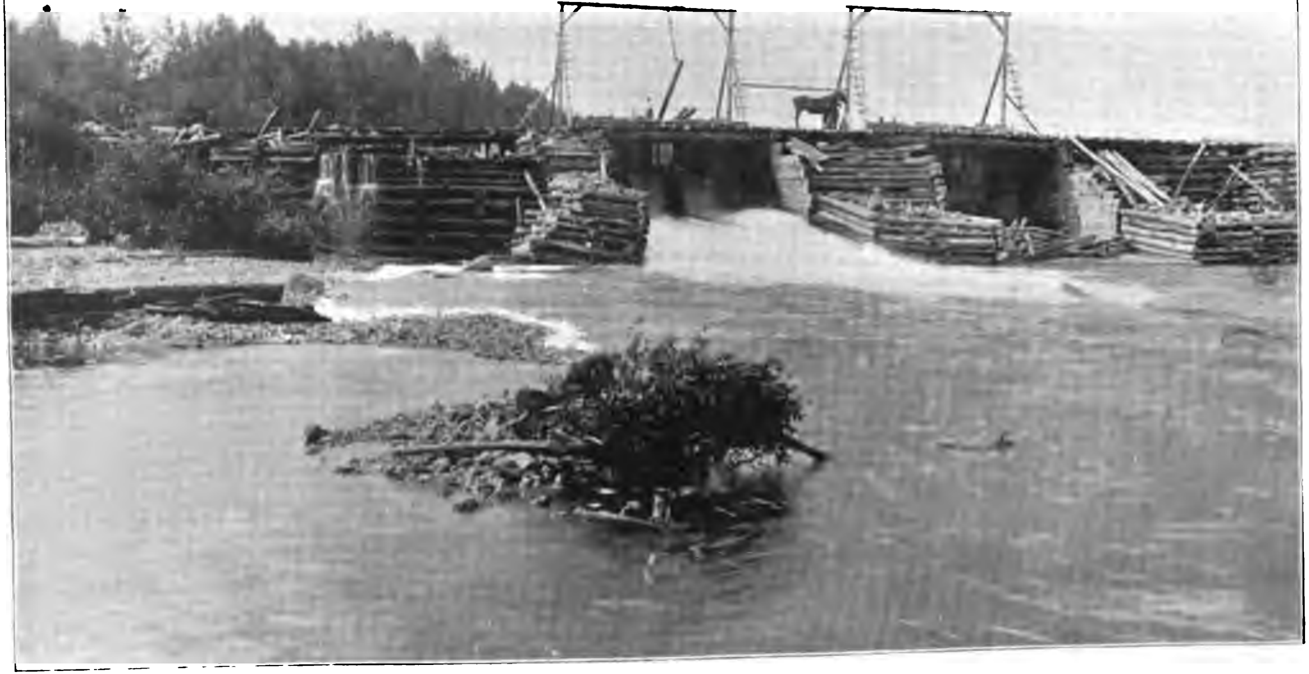

Plate C.—Lumbermen's Dam on the Cedar River.

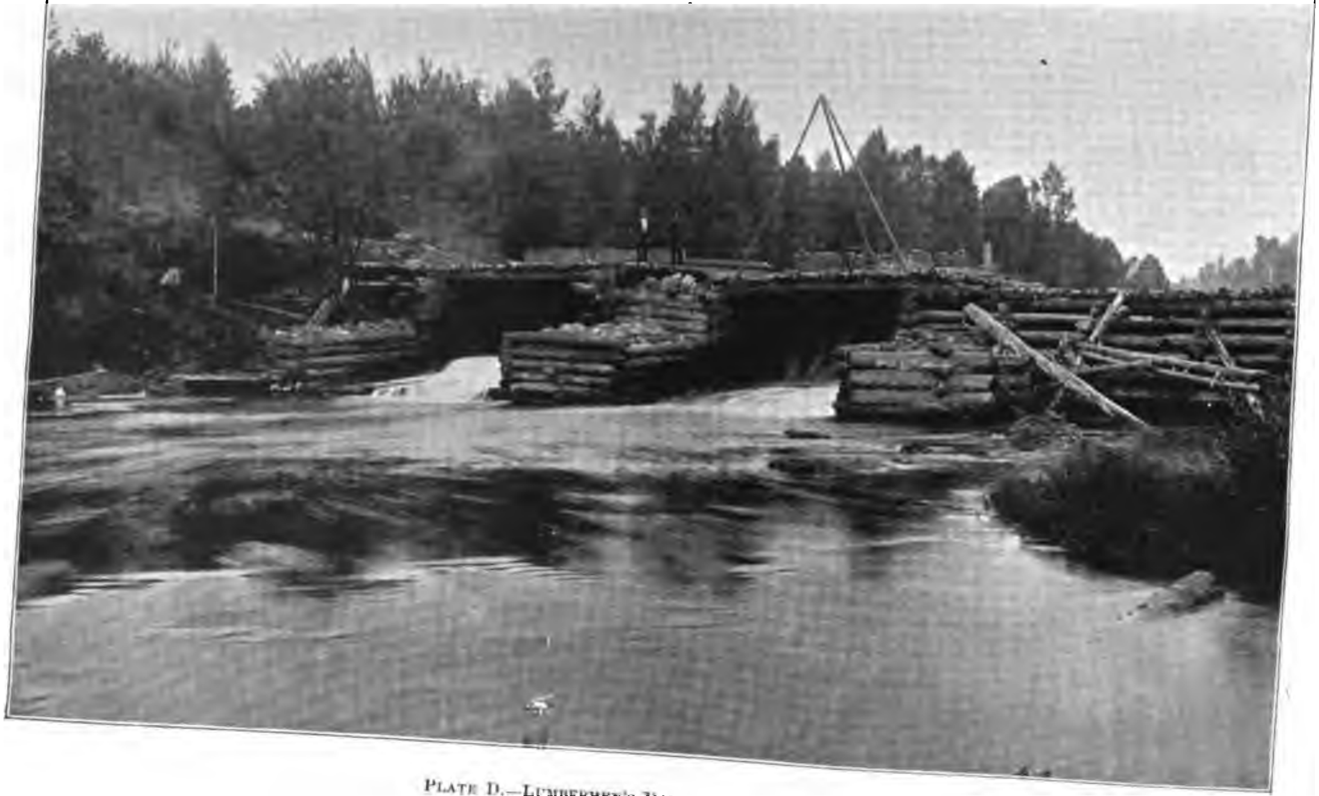

PLATE D.—LUMBERMEN'S DAM ON INDIAN RIVER.

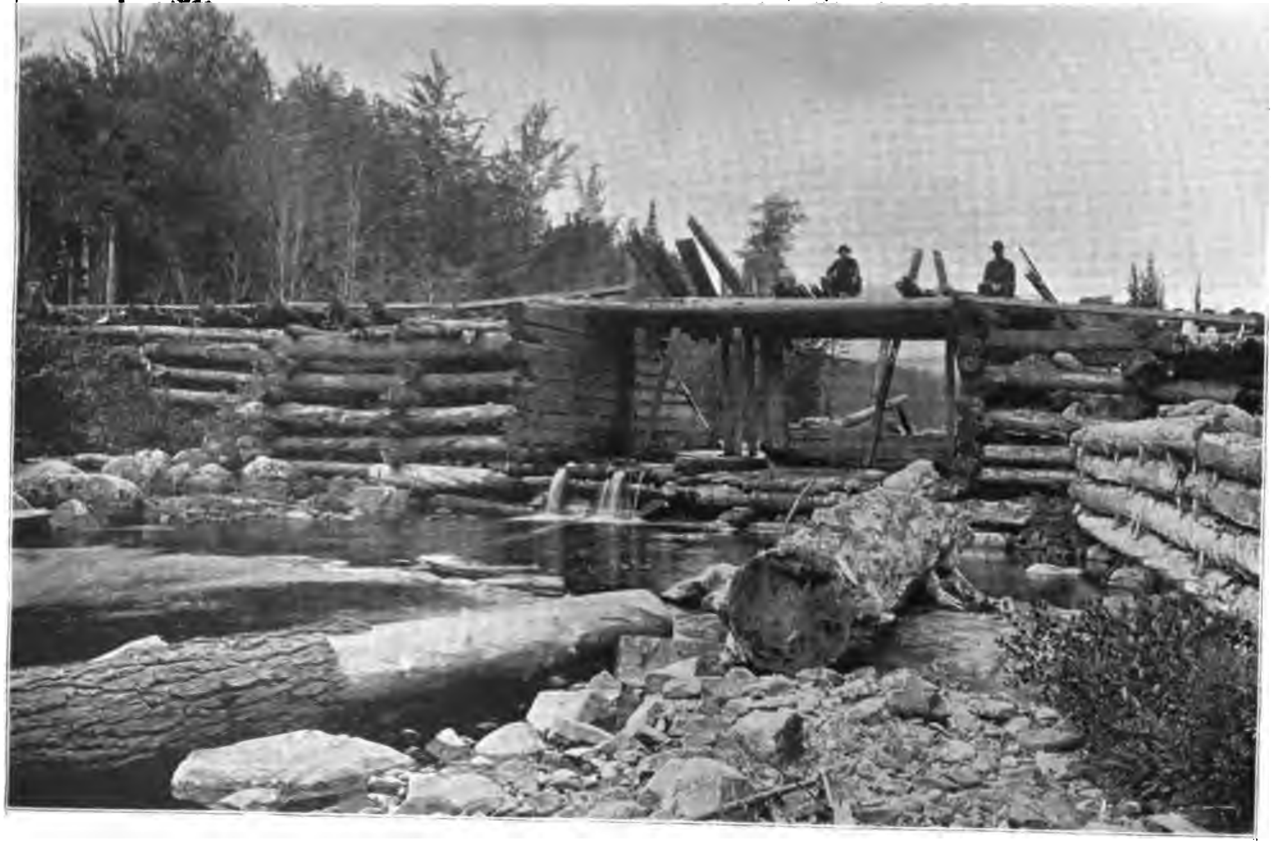

Plate E.—Lumbermen's Dam at Foot of Lily Pod Pond (below Catlin Lake),

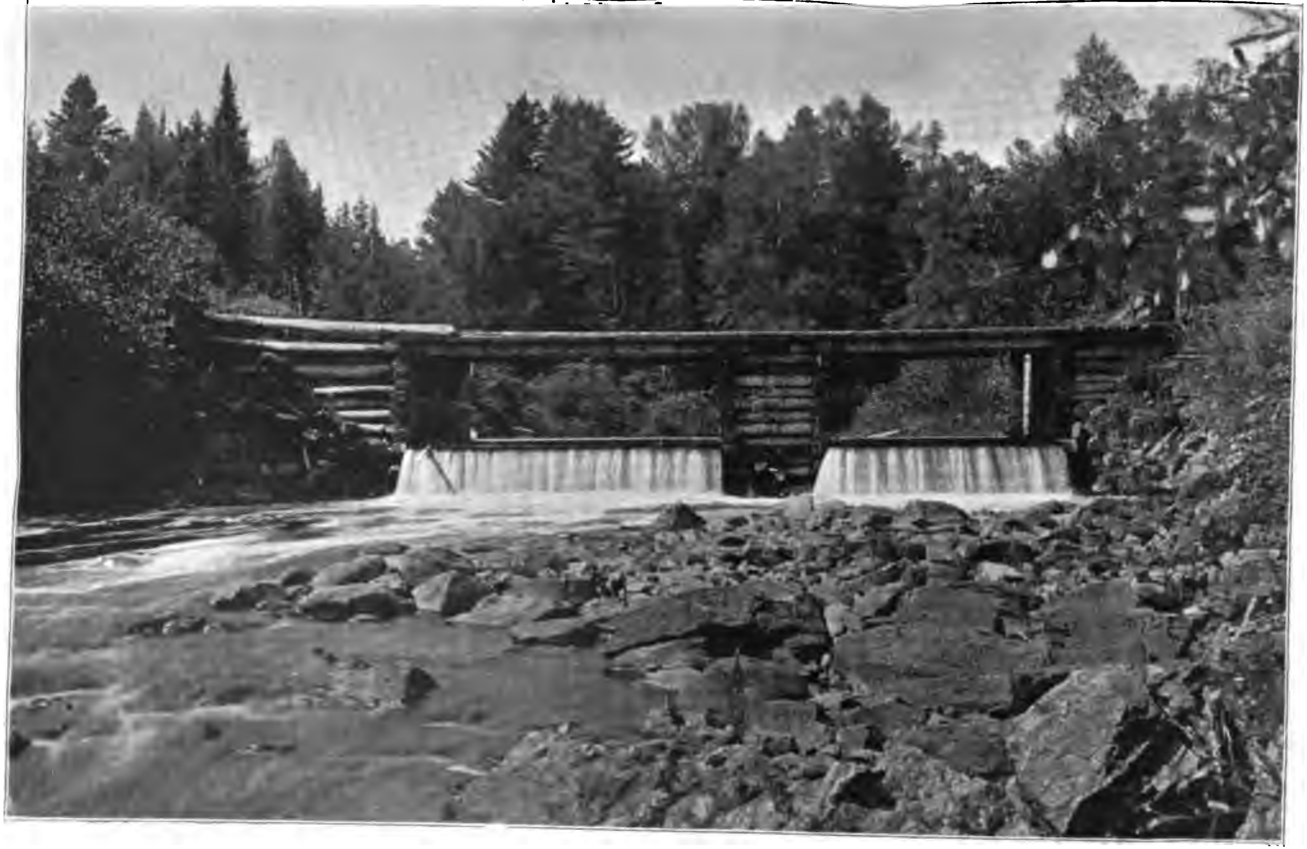

Plate F.—Lumbermen's Dam Below Lake Pleasant.

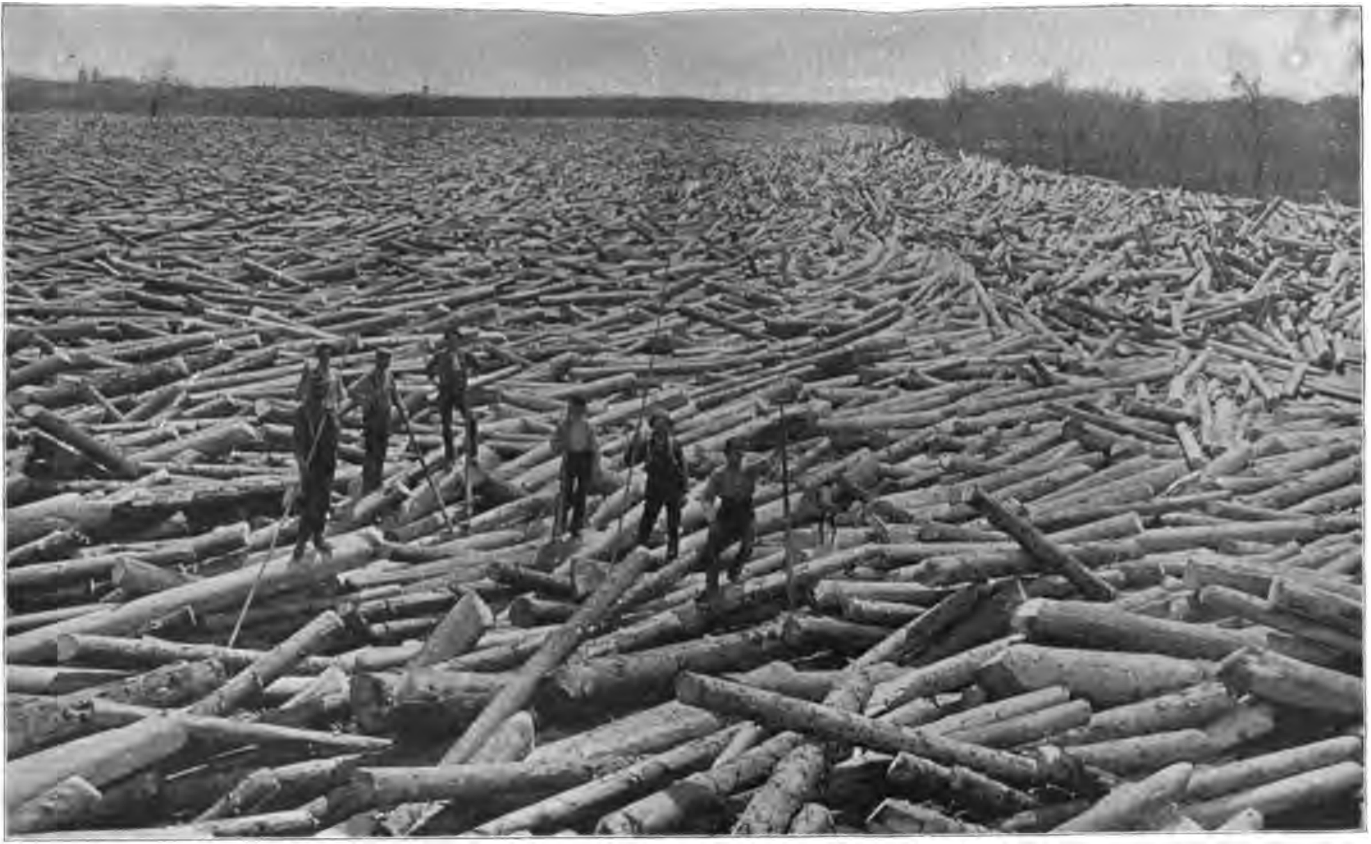

Plate G.—A Log Jam at the Big Boom Above Glens Falls.

the minimum to allow the tributary streams of the Hudson is a liberal allowance.*

At first thought it may appear that streams issuing from lakes, as many of those of the Upper Hudson do, will maintain higher minimum flows than those just given. This is, however, entirely a question of relation. If the area of the lake is large in comparison with that of the tributary watershed, it may happen, in a warm summer, that the evaporation from the water surface will equal, or even exceed the inflow for short periods; in which case the outflow for the time being may be nothing.

There are, moreover, two reasons why we should make our flow line somewhat higher than twelve inches, namely in order (1) to supply a certain amount in April and early in May for log driving; and (2) to compensate for the losses of evaporation from the reservoir water surfaces. Let us discuss these two points in detail.

THE LUMBER INTERESTS OF THE HUDSON VALLEY.

For the last forty to fifty years the lumber interests of the Upper Hudson valley have been an extensive and important source of wealth to a large portion of the State; they will continue to be for many years to come.† Those interests have developed, for the purpose of log-driving in the spring, a storage in the Upper Hudson area, which in the aggregate amounts to at least 4,000,000,000 cubic feet. This water is used about May 1, or a little before — the dams being so arranged as to permit of drawing off quickly. As permanent structures little can be said in favor of these lumbermen's dams, although it must be recognized that while cheaply constructed, they have fulfilled the purpose for which they were intended. They are, however, of too temporary character for a permanent system, while their flow lines are so low as, in the most of cases, to only utilize a small per cent. of the total yield. Nevertheless, inasmuch as they are necessary to the carrying on of the lumber business of the stream, if they are replaced by more pretentious permanent structures, the new dams must, as a mere matter of justice, be arranged with reference to drawing off at each location, whatever amount of water, as determined by the surveys, the original lumbermen's dam furnished at that place — and no more. Such arrangements can be made without material addition to the expense.

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* The foregoing statements of minimum flow of streams, with much other information of similar character, which has been compiled from various sources, can be found in Mr. Vermeule's report on the Water Supply and Water Power of New Jersey, pp. 103-106.

† For the information of those citizens of the Commonwealth who suppose that the State is now the owner of all the forest areas in the Adirondack region it may be pointed out that there are large private holdings there by individuals and clubs, on which systematic forestry will be gradually applied in the years to come. The river is the natural outlet to market of the products of these lands.

Plates C, D, E, and F, illustrate the style of dam now in use by the lumbermen; while Plate G shows a log jamb at the big boom above Glens Falls.

The 4,000,000,000 cubic feet required for the logging interests amounts to 1.46 inches on 1,183 square miles; and our flow lines must be located with reference to furnishing this quantity in the year of minimum yield.*

DEMANDS OF EVAPORATION.

Second, as to the demands of evaporation from the water surfaces of the proposed reservoirs.

According to the elaborate evaporation experiments of Mr. Fitzgerald as conducted for many years at Boston, the total for the year at that place, as a mean, is 39.5 inches, distributed through the several months as appears in the table on page 131.

In the Upper Hudson valley, with a lower mean temperature than at Boston, the annual evaporation will be somewhat less.†

As the best approximation that can be made before our topographical surveys are completed, we may take the total area of reservoir surfaces as seventy-five square miles, or at about one-sixteenth of the total area to be controlled.

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* For a statement of the market logs received at the big boom on the Hudson from 1851 to 1884, see the First Annual Report of the Forest Commission, 1885, page 65. Also see later reports for statements of the number from year to year for several of the years since 1884.

† The Boston experiments as made near the sea coast are probably not entirely applicable to the conditions in New York. For recent evaporation determinations in this State, see the Annual Report of the Executive Board of the city of Rochester for years from April 6, 1894, to December 31, 1895 (19th and 20th Annual Reports).

Taking the mean evaporation of this region at thirty-two inches annually, we would have two inches over the whole controlled area as the annual loss by evaporation.

We, however, gain something from the rainfall on the seventy-five square miles of water surface which is all utilized for storage; while of the rainfall on the balance of the area, only about fifty per cent. of the total for the year appears in the runoff, as may be seen on reference to Tables 1, 2 and 3 in comparison with Table No. 6. Again, the runoffs given in Table 6 are with reference to the evaporation from the water surfaces as they now exist. The small gain obtained by neglecting these several items may be left as a provision for leakage, percolation and other indeterminate possible sources of loss.

For convenient adjustment of the evaporation losses to our computation we take the losses per month at Boston, as per Mr. Fitzgerald, and deduce therefrom the proportionate part of the total represented by each month's loss. We have then the following tabulation in which the last column represents the loss in inches each month over the controlled watershed:

	Monthly evaporation at Boston, in inches.	Proportionate part of whole.	Inches on watershed.
December.	1.51	0.0382	0.08
January.	0.96	0.0245	0.05
February.	1.05	0.0266	0.05
March.	1.70	0.0430	0.09
April.	2.97	0.0752	0.15
May.	4.46	0.1130	0.22
June.	5.94	0.1402	0.28
July.	5.98	0.1513	0.30
August.	5.50	0.1392	0.28
September.	4.12	0.1044	0.21
October.	3.46	0.0876	0.18
November.	2.25	0.0568	0.11
Total.	39.50	1.0000	2.00

ADJUSTMENT AFFORDED BY THE RESERVOIR SYSTEM.

We may now compute the effect on the reservoirs, of drawing from month to month of the year 1891, the amount of water required to maintain stream flow to at least 0.45 cubic feet per second per square mile of drainage area during the storage period; and also to maintain 4,500 cubic feet per second at Mechanicville for the actually observed low water period which we have already discussed on pages 113-114. We will assume our flow line at 13.5 inches on the whole area, and that we start on the first of December of the water year of 1891 with two inches in the reservoirs, as the runoff record of Table No. 6 shows we may safely do. We have then Table No. 9.

Analyzing Table No. 9 we learn that under the actually existing conditions, a system of reservoirs with flow line proportioned to a storage of 13.5 inches on the watershed would have carried us through the low water of 1891, leaving 0.22 inches in the reservoirs at the end of that year, and also leaving the Hadley reservoir full as a contingency against low water in the winter. The method of computation followed is so simple as to require no explanation any further than to point out that for the month of April it is assumed that the use for log-driving would all take place in the latter part of the month and that before its beginning 0.35 inches passed out to maintain the stream.

In the same way we have computed in Table No. 10 the adjustments that could have been realized from a similar system of reservoirs in 1895.

Analyzing Table No. 10, we learn that even in 1895, with the minimum runoff of 17.46 inches for the year and with two inches in the reservoirs at the beginning of the water year, we would have been able to maintain 4,500 cubic feet per second at Mechanicville and still end up on November 30, with 1.22 inches in the general storage system above the Hadley reservoir. But this would have required a draft on the Hadley reservoir of 0.28 inches in October, which, however, would have been more than balanced by the excess flow of November with the result of also ending the water year with Hadley full.

TABLE NO. 9; SHOWING THE ADJUSTMENT OF FLOW OF HUDSON RIVER IN 1891, WITH A SYSTEM OF RESERVOIRS STORING 13.50 INCHES.

(All in inches on the tributary watershed of 1,183 square miles.)

MONTH.	(1.) Runoff.	(2.) Evaporation from reservoirs.	(3.) For driving logs.	(4.) *Amount to stream.	(5.) Sum of columns (2), (3) and (4).	(6.) Excess.	(7.) Deficiency.	(8.) Quantity in reservoirs at end of month.	(9. Taken from Hadley reservoir.
December	0.83	0.08	....	0.50	0.58	0.25	....	2.25	....
January	2.12	0.05	....	0.50	0.55	1.57	....	3.82	....
February	2.70	0.05	....	0.50	0.55	2.15	....	5.97	....
March	4.55	0.09	....	0.50	0.59	3.96	....	9.93	....
April	4.97	0.15	1.46	0.35	1.96	3.01	....	12.94	....
May	1.42	0.22	....	0.64	0.86	0.56	....	13.50	....
June	0.79	0.28	....	2.02	2.30	....	1.51	11.99	....
July	0.60	0.30	....	2.71	3.01	....	2.41	9.58	....
August	0.68	0.28	....	2.47	2.75	....	2.07	7.51	....
September	0.51	0.21	....	2.83	3.04	....	2.53	4.98	....
October	0.38	0.18	....	3.33	3.51	....	3.13	1.85	....
November	1.01	0.11	....	2.53	2.64	....	1.63	0.22	....
Total	20.56	2.00	1.46	18.88	22.34	11.50	13.28	....	....

* For the deficiency months the quantities of column (4) are the sums of the deficiency plus the natural runoff as per column (1). Thus for June, 1891, the actual deficiency at Mechanicville was 1.23 inches, but since we have, as per Table No. 9, retained the natural flow for that month of 0.79 inches in the reservoir, we must add that quantity to the 1.23 inches in order to obtain the total quantity going out, which gives 2.02 inches as per column (4).

TABLE NO. 10: SHOWING THE ADJUSTMENT OF FLOW OF HUDSON RIVER IN 1895, WITH A SYSTEM OF RESERVOIRS STORING 13.50 INCHES.

(All in inches on the tributary watershed of 1,183 square miles.)

MONTH.	(1.) Runoff.	(2.) Evaporation from reservoirs.	(3.) For driving logs.	(4.) *Amount to stream.	(5.) Sum of columns (2), (3), and (4).	(6.) Excess.	(7.) Deficiency.	(8.) Quantity in reservoirs at end of month.	(9.) Taken from Hadley reservoir.
December	1.12	0.08	....	0.50	0.58	0.54	....	2.54	....
January	0.99	0.05	....	0.50	0.55	0.44	....	2.98	....
February	0.82	0.05	....	0.50	0.55	0.27	....	3.25	....
March	1.08	0.09	....	0.50	0.59	0.49	....	3.74	....
April	5.91	0.15	1.46	0.40	2.01	3.90	....	7.64	....
May	1.76	0.22	....	0.55	0.77	0.99	....	8.63	....
June	0.70	0.28	....	2.30	2.58	....	1.88	6.75	....
July	0.66	0.30	....	2.55	2.85	....	2.19	4.56	....
August	1.00	0.28	....	1.58	1.86	....	0.86	3.70	....
September	0.65	0.21	....	2.42	2.63	....	1.98	1.72	....
October	0.69	0.18	....	2.51	2.69	....	2.00	0.00	0.28
November	2.08	0.11	....	0.75	0.86	1.22	....	1.22	....
Total	17.46	2.00	1.46	15.06	18.52	8.05	8.91	....	0.28

* For explanation of column (4) see foot note to Table No. 9.

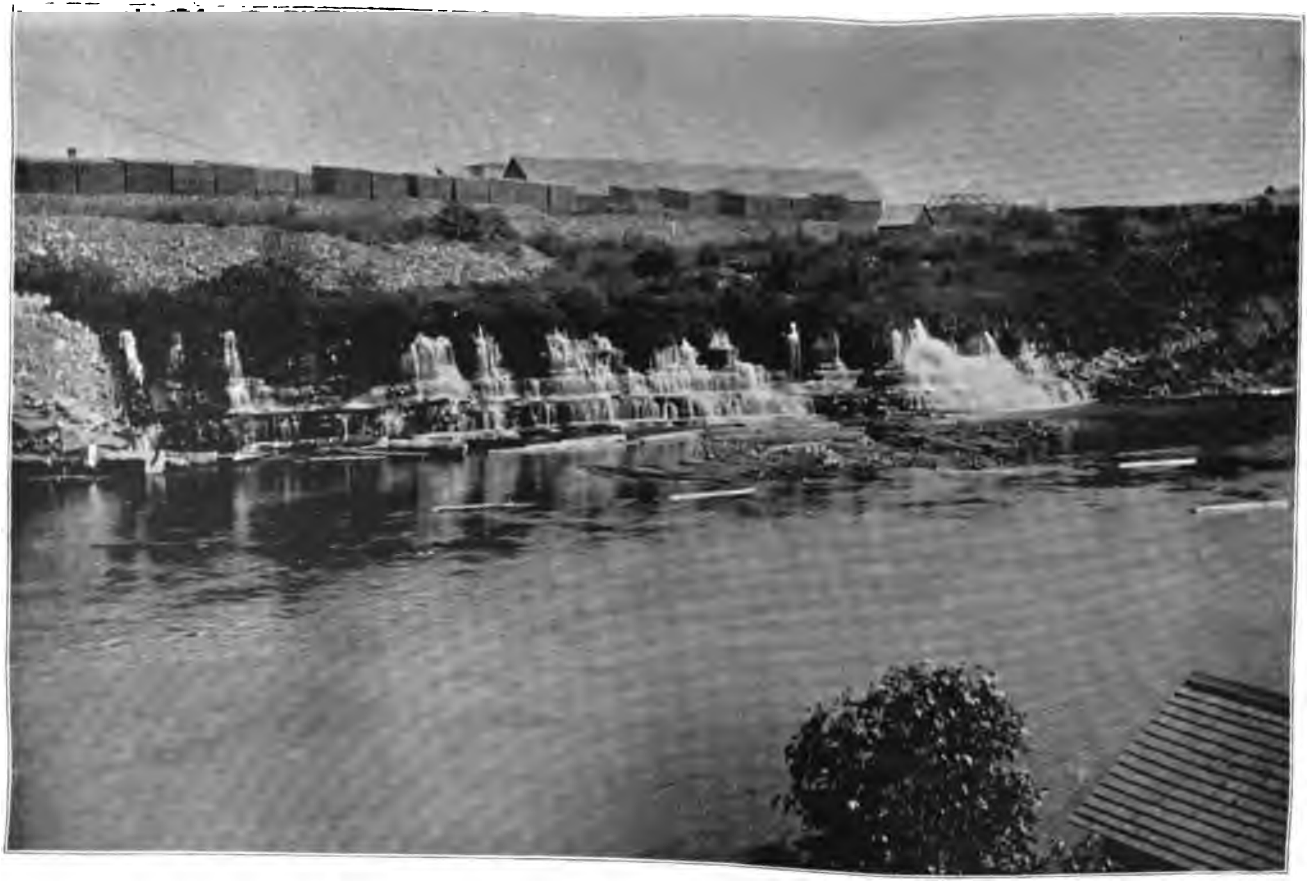

Plate H.—Leakage from the Glens Falls Feeder.

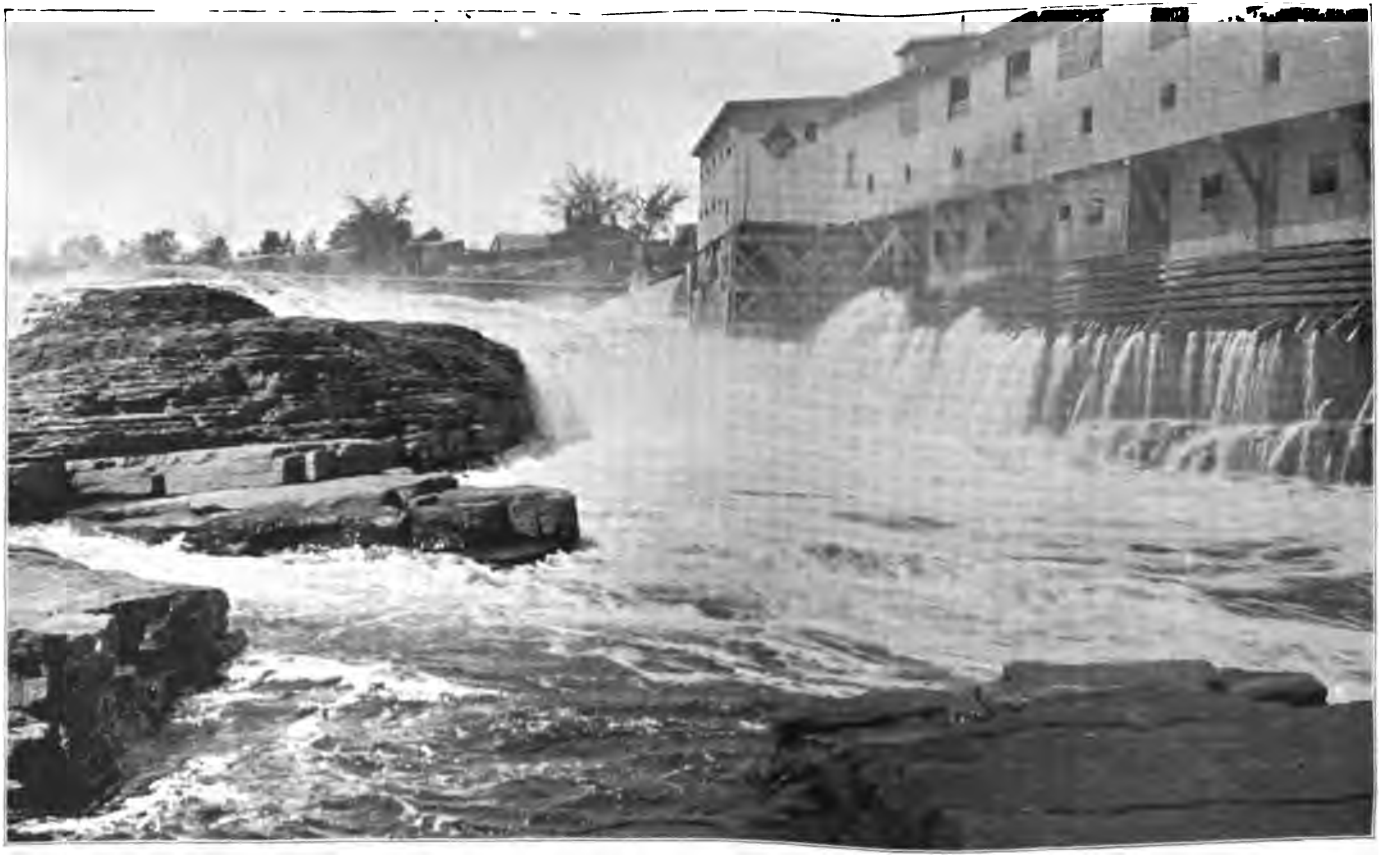

Plate J.—Waste of Power at Finch, Pruyn & Co.'s Sawmills at Glens Falls.

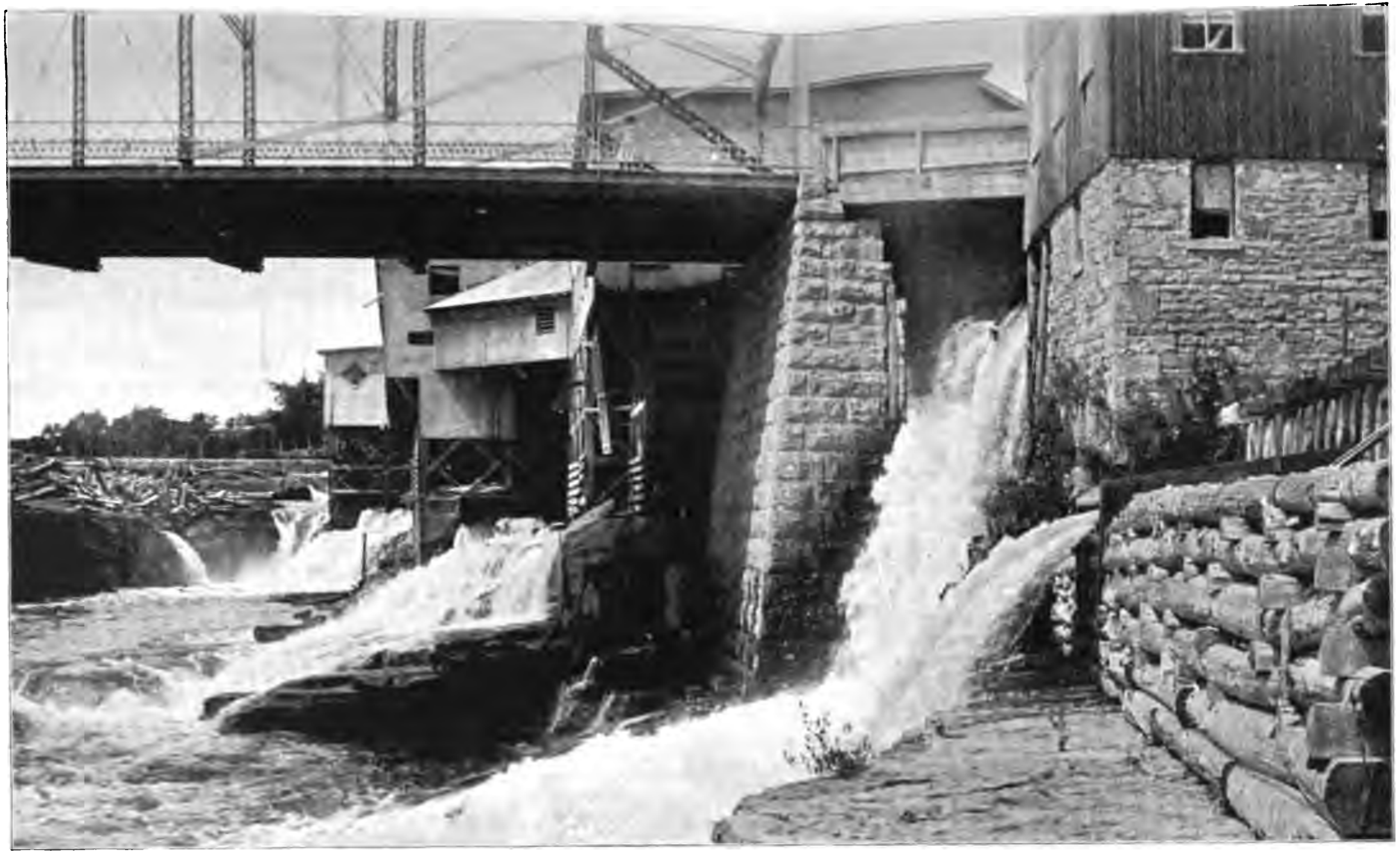

Plate K.—Another View of Finch, Pruyn & Co.'s Mills, Showing Waste of Power.

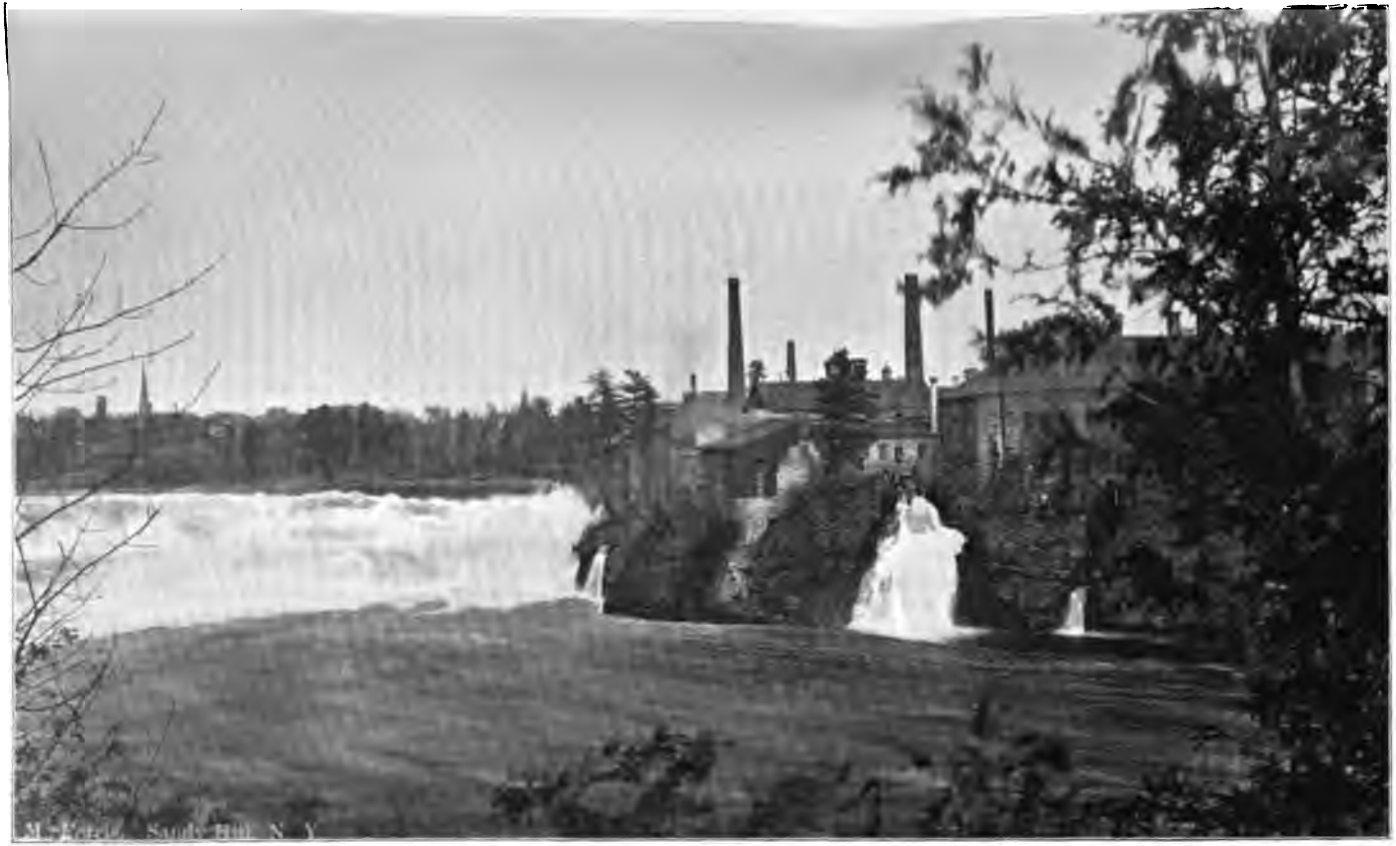

Plate L.—Waste of Power at Baker's Falls by Use of Water from Two Levels.

We conclude then that 13.50 inches on the whole area of the 1,183 square miles, with the Hadley reservoir as a regulator and reserve for contingencies, would be ample to maintain 4,500 cubic feet per second at Mechanicville for any period for which we thus far have definite information from gagings. The possibility of drier years than any thus far observed is pointed out on page 116.

WATER POWER ON THE LOWER SCHROON RIVER.

There is, however, one other contingency to which we may now direct attention.

The Schroon River Pulp Company, at Warrensburg, on the Schroon river, have developed a water power capacity of 580 cubic feet per second, which is, however, at least 280 cubic feet per second beyond the permanent power of the stream. The arrangements for that stream should include the maintaining of at least 300 cubic feet per second as a minimum, as otherwise we cripple an important manufacturing industry of that locality. Our assumed 0.45 cubic feet per second per square mile for minimum flow during the storage period would give that stream about 225 cubic feet per second. The unregulated area between the lowest reservoir on the stream and Warrensburg, of about sixty square miles, may be relied upon to yield at least fifty-five to sixty cubic feet per second more, or we have a total of say 280 cubic feet per second. The deficiency below the requirement would, therefore, be 300 — 280 = 20 cubic feet per second. The excess flows of either March and April or of April and May, would furnish this for two months of the storage period. For the other four months twenty cubic feet per second will amount to a total of 207,360,000 cubic feet, which small amount can be furnished from the reservoirs without affecting the general result.

PRESENT DIVERSION FOR THE SUPPLY OF THE CHAMPLAIN CANAL.

We may now take up the matter of the present diversion for the supply of the Champlain canal.

The Champlain canal is fed from the Hudson river at two points, namely, (1) from the Glens Falls feeder, which connects with the river about two miles above Glens Falls; and (2) from the Saratoga dam at Northumberland.

The length of the Glens Falls feeder, from the guard lock at its head to where it enters the Champlain canal, about two miles above Fort Edward, is 6.92 miles. From this point the water in the canal flows both north and south. The distance along the canal, from where the feeder enters, north to the guard lock at the entrance to Wood creek above Fort Ann, is 16.13 miles. The water passing through this section flows through Wood creek to Lake Champlain and is lost to the Hudson river.

From the feeder south to the Hudson river, at the Saratoga dam, the distance is 15.68 miles. The water flowing through this section is returned, less the evaporation from the surface, to the river at that dam.

The total length of canal fed by the Glens Falls feeder is, then, 16.13 + 15.68 = 31.81 miles.

At the Saratoga dam the canal crosses through the pond formed by the dam — from the east side to the west side, and again passes out of the river, taking a full supply therefrom at the village of Northumberland.

From the guard lock at Northumberland to the guard lock where the canal enters the Mohawk river at Cohoes, the distance is 27.06 miles. The water for this section, by passing into the Mohawk, finally reaches the Hudson above the Troy dam.

The canal crosses the Mohawk river at Cohoes, taking water therefrom to supply the section from Cohoes to near West Troy, a distance of 2.36 miles.

There is also a side-cut connection from the canal to the Hudson river at Waterford, whereby boats may pass from the canal into the pond above the Troy dam.

Ever since the construction of the Glens Falls feeder there have existed serious leaks through the seamy limestone rock in which the feeder is excavated at and below the village of Glens Falls. It is claimed that the losses through these seams have gradually increased, until, at the present time and for several years past, they have amounted to about fifty per cent. of the total flow into the feeder at the guard lock.

This leakage has been repeatedly complained of by the owners of water power at Glens Falls, and several attempts to check it have been made, but thus far without much avail. The river falls thirty-eight feet at Glens Falls and the owners of the water power there claim that this leakage, which is practically all below the falls, is a material detriment to their water power which ought not to exist. In order to determine the amount of this leakage, at present, as well as the relation which it bears to the question of a material increase in the flow of the Hudson river by storage, a series of gagings of the flow of the feeder were undertaken early in October of the present year, the details of which are as follows:

Arrangements were first made with the Division Superintendent to maintain a uniform feed for several days before the gagings began, as well as during the days when they were actually being made, and points established for verifying the uniformity of the feed during the time of gagings, in this way assuring the feeder well in train for the required delivery for that season of the year.

A series of accurate cross-sections were then made at points both above and below the leakage, and a large number of current meter readings taken from a foot bridge, thrown temporarily across the feeder at each section. The results so obtained reduced to cubic feet per second are as follows:

(1.) On October 8, 1895, the flow in the feeder, just below the guard lock at the feeder dam, was 383 cubic feet per second.

(2.) On the same date, the flow at Change bridge No. 13, about one-half mile from the feeder dam, was 364 cubic feet per second.

Gagings (1) and (2) are above any serious leaks.

(3.) On October 9 and 10, the flow at Coole and Clark's lime works, just above the waste weir, was 213 cubic feet per second.

This section is below the main leaks which are illustrated by the photograph Plate H.

In this picture the feeder is near the lumber piles at the top of the river bank on the north side of the river, the view having been taken from the south side.

(4.) On October 10, the flow at the old Sherman sawmill, about one-half mile below section (3), was 191 cubic feet per second.

(5.) On October 11, the flow at Sandy Hill, just above the Kenyon and Baldwin head race, was 182 cubic feet per second.

Section (5) is just above the locks at Sandy Hill, and the water passing this point may be considered as all going to the canal less the slight losses from evaporation, etc., from the head of the feeder locks to their foot.

(6) A section was also taken October 11, in the Champlain canal, a short distance to the north of where the feeder enters, for the purpose of determining the amount of water permanently lost to the Hudson river by being diverted through this section of the canal to Lake Champlain. The gaging showed seventy-four cubic feet per second.

Analyzing these gagings it is learned that between (1) and (2) the loss is small; and that the main leakage between (2) and (3), amounted in October, with the losses from evaporation, etc., to 151 cubic feet per second. The difference between sections (1) and (5), which may be taken as including about all the losses from the canal, is 201 cubic feet per second. The water delivered through the locks into the Champlain canal is, therefore, only about forty-seven per cent. of the quantity entering the feeder at the guard lock.

Between sections (2) and (3) the loss is 40 per cent. of the whole amount entering; and the quantity of 151 cubic feet per second as lost between these sections, may be taken as the quantity unnecessarily diverted, by reason of the leakage, around the Glens Falls, and lost to the users of the water power there.

It is also learned from gaging (6), that of the 182 cubic feet per second actually delivered to the Champlain canal by the feeder, seventy-four cubic feet per second is permanently lost to the river, and 108 cubic feet per second less the loss from evaporation, etc., is returned to the river at the Saratoga dam.

It will be observed that these gagings were taken in October when the losses from evaporation from the water surface, growing vegetation, etc., are quite small. We may conclude, therefore, that earlier in the season the demands on the feeder are somewhat greater. In verification of this view it may be stated that during a very warm week early in September, observations at section (1) of the preceding series, showed an outflow through the feeder of 415 cubic feet per second, as against 383 cubic feet there a month later.

Taking into account the demands of evaporation and growing vegetation along the banks of the canal, it is safe to say that while the leakage remains as at present, there will pass out of the river, through the Champlain feeder during the months of June, July and August, an average of 450 cubic feet per second, of which 220 cubic feet per second will be lost above the head of the locks at Sandy Hill, leaving 230 cubic feet per second for the supply of the canal.

The mean supply in May will be about the same as that of September; while the November demands will be somewhat less than the October.

We may take then, for the months of canal navigation, under present conditions, the following as the approximate monthly means:

May	415	cubic	feet	per	second
June	450	"	"	"	"
July	450	"	"	"	"
August	450	"	"	"	"
September	415	"	"	"	"
October	383	"	"	"	"
November	372	"	"	"	"
Mean	419	"	"	"	"

Proceeding in the same way we find the losses of the Glens Falls feeder above Sandy Hill to equal 213 cubic feet per second, of which, as already shown, 151 cubic feet per second is lost in a short reach of feeder at and below Glens Falls village.

We have, then, 419 — 213 = 206 cubic feet per second as the mean supply for the whole season to that section of the canal, 31.81 miles in length, which extends from Wood creek above Fort Ann to the Saratoga dam. Of this 206 cubic feet per second we have seen that 74 cubic feet per second passes north in October. For the entire navigation season we may say that eighty cubic feet per second flows in that direction, leaving, then, 206 — 80 = 126 cubic feet per second, less the various indeterminate losses, to be returned into the river at Saratoga dam.

Let us now examine as to the supply from Northumberland to Cohoes.

We learn from the foregoing discussion that the mean supply for a section of canal 31.81 miles in length is 206 cubic feet per second. Reasoning somewhat rapidly we may say, as an approximation, that the supply to the lower section is in proportion to the length. This proposition may not be exactly true, but in the absence of gagings as a starting point, it may be taken without serious error. We have, then, the proportion

$$31.81 : 27.06 : 206 : 175,$$

whence we learn that the approximate supply of the lower section is 175 cubic feet per second; or adding something for Waterford sidecut, not included in the foregoing, we have a total of say 190 cubic feet per second. This quantity of water is permanently diverted from the water powers at Stillwater and Mechanicville.*

Further, in regard to the leakage of the Glens Falls feeder, it may be remarked that gagings to determine the quantity lost were made by Ellis B. Noyes, C. E., in September and October, 1887.

Mr. Noyes selected two sections for his gagings: the upper section, just above Glen street bridge, at Glens Falls; the lower, near the drawbridge, used for transferring lumber across the canal above Sandy Hill. His results are as follows:

On September 19, 1887, the flow at the upper section was 437 cubic feet per second; September 26, 438 cubic feet per second;

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* The evaporation which is small in October is not taken into account in this rapid discussion.

September 27, 440 cubic feet; September 28, 434 cubic feet; and on October 6, it was 406 cubic feet per second.

On September 27, 1887, the flow at the lower section was 243 cubic feet per second; September 28, 234 cubic feet; September 30, 238 cubic feet; and on October 6, it was 202 cubic feet per second. Mr. Noyes therefore concluded that the loss from leakage was at that time 200 cubic feet per second. He used both floats and current meter.

Since that time considerable work has been done towards stopping these leaks, and the slight decrease in the leakage — indicated by this year's gagings, may be in some degree due to such work.

DIVERSION FOR THE ENLARGED CHAMPLAIN CANAL.

The proposed enlargement contemplates an additional depth of one foot, the water surface remaining the same. There will be no change, therefore, in the evaporation loss, but the additional depth will tend to increase the absorption, percolation, and leakage loss. Also assuming some increase in business, with the consequent demand for additional water for lockage, and we may place the diversion for the enlarged canal at thirty per cent. greater than at present.*

On this basis we have, for the section supplied by the Glens Falls feeder, a mean supply for the whole season of 206 + 62 = 268 cubic feet per second; and for the section from Northumberland to Cohoes a mean supply of 180 + 57 = 247 cubic feet per second.

In the enlarged canal the total loss to the Hudson river of that portion flowing north from the Glens Falls feeder to Lake Champlain will be, as a mean for the entire season, 104 cubic feet per second.†

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* Questions of the losses to which canals are subject will be discussed at length in a special report on the Water Supply of the Enlarged Canals as a whole, and are therefore omitted here.

† These results are subject to verification by a more complete series of gagings to be made in the summer of 1896.

RENTAL VALUE OF WATER FOR POWER ON THE HUDSON RIVER.

In order to determine the value of this water to the manufacturing interests on the Hudson river, let us now examine as to the rental value of water when used for power elsewhere, after which we will contrast the cost of power produced with water as the motive force, with that of steam for the same purpose.

Referring to the U. S. census reports of 1880 we find in the special report on water power, statements of the rental value of power at nearly all the large developments of this country. Confining ourselves to New York and adjacent States, we may select the following:

Lawrence, Massachusetts.

This power of twenty-eight to thirty-two feet head controlling the whole flow of the Merrimack river, is owned by the Essex Company. The total power developed may be taken at from 9,000 to 10,000 horse power.

Originally, a mill power was valued at about $15,000 and the early grantees paid about $10,000 down and continue to pay about $300 per annum. Without going into the detail a mill power may be briefly stated as the right to use thirty cubic feet of water per second on twenty-five feet head, or its equivalent on greater or less heads.

We have then, a mill power as equivalent to eighty-five gross horse power, or, on seventy-five per cent. efficiency, to 63.75 horse power net. On this basis the annual rental of a gross horse power is $10.59, or of a net horse power (seventy-five per cent. efficiency), $14.13.

Recently, however, the price has been higher. The Essex Company finally adopted the plan of leasing power for an annual payment, without an original cash payment, and the new mills pay an annual rental of $1,200, per mill power, which is equivalent to $14.10 per gross horse power per annum, or, with seventy-five per cent. efficiency, to $18.82 per net horse power.

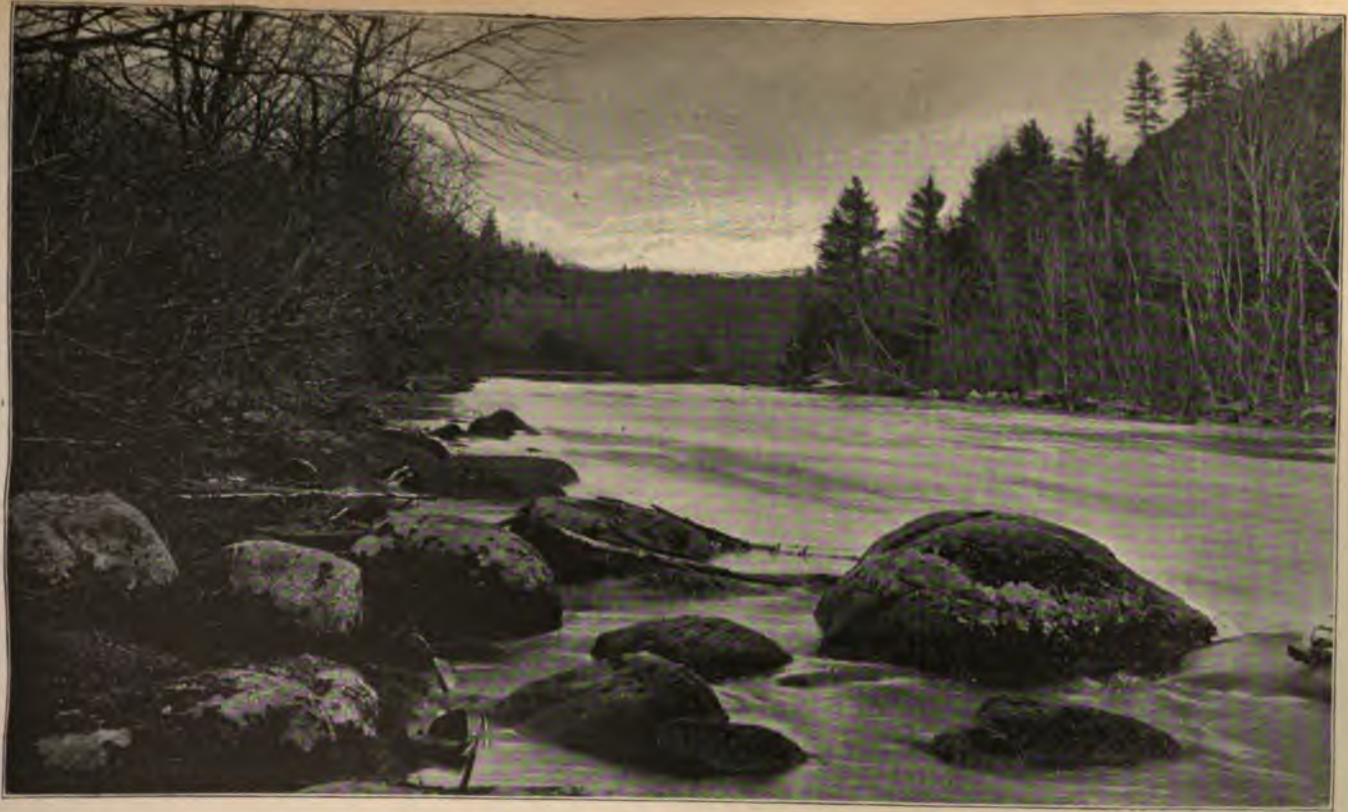

PLATE M.—LOOKING UP STREAM AT TUMBLEHEAD FALLS.

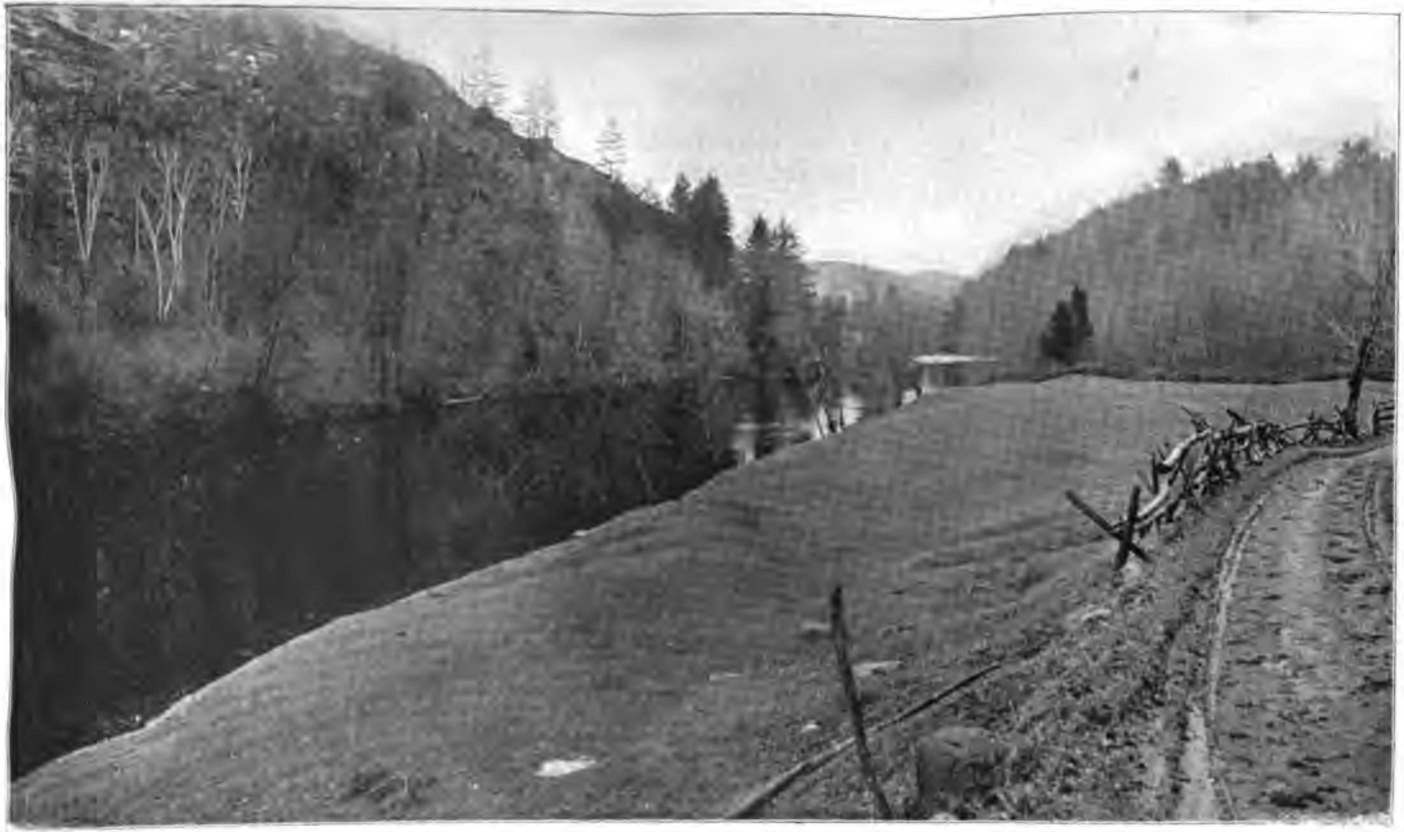

PLATE N.—ANOTHER VIEW AT TUMBLEHEAD FALLS, LOOKING DOWN STREAM.

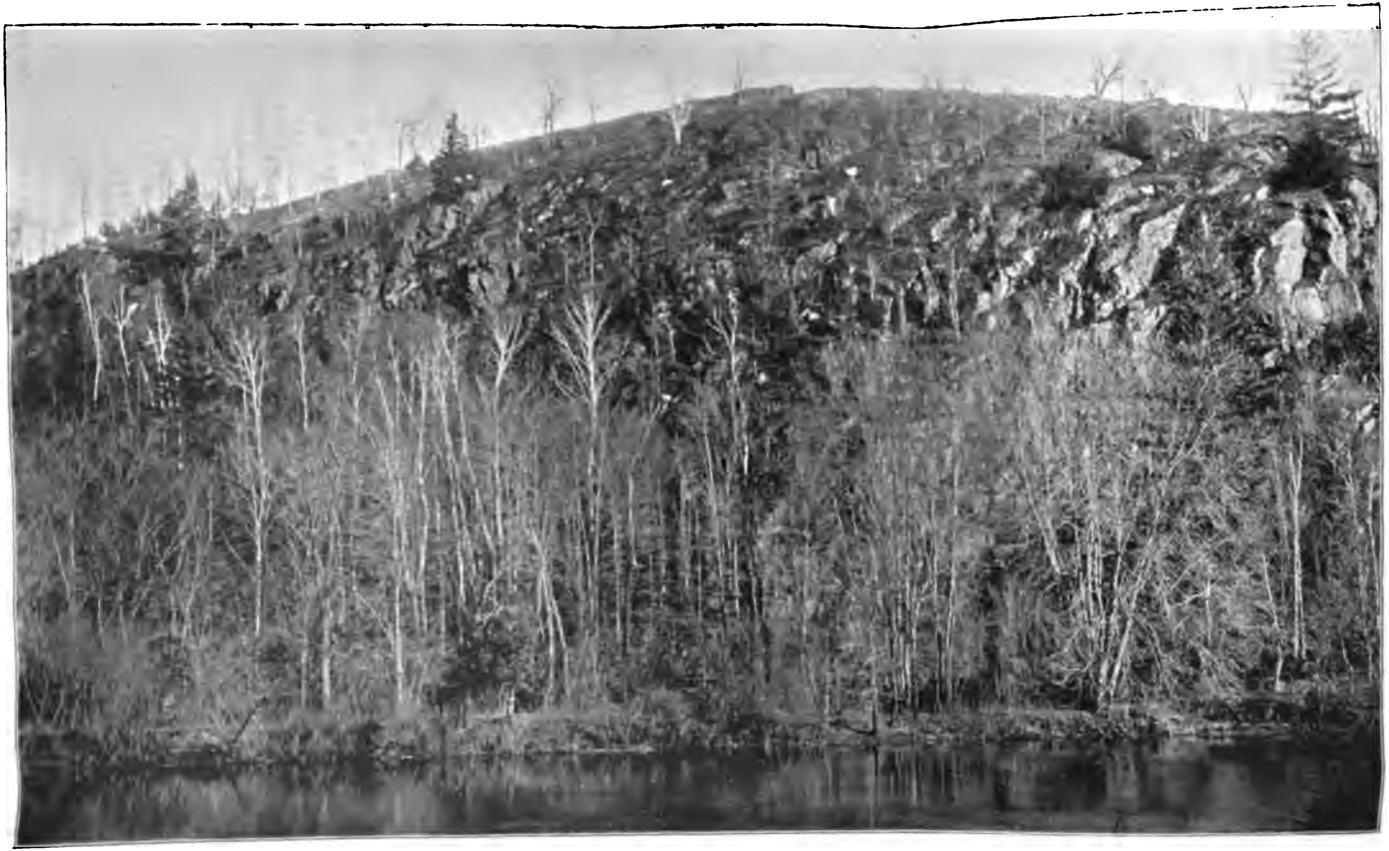

PLATE O.—THE GRANITE HILL AT EAST END OF PROPOSED TUMBLEHEAD FALLS DAM.

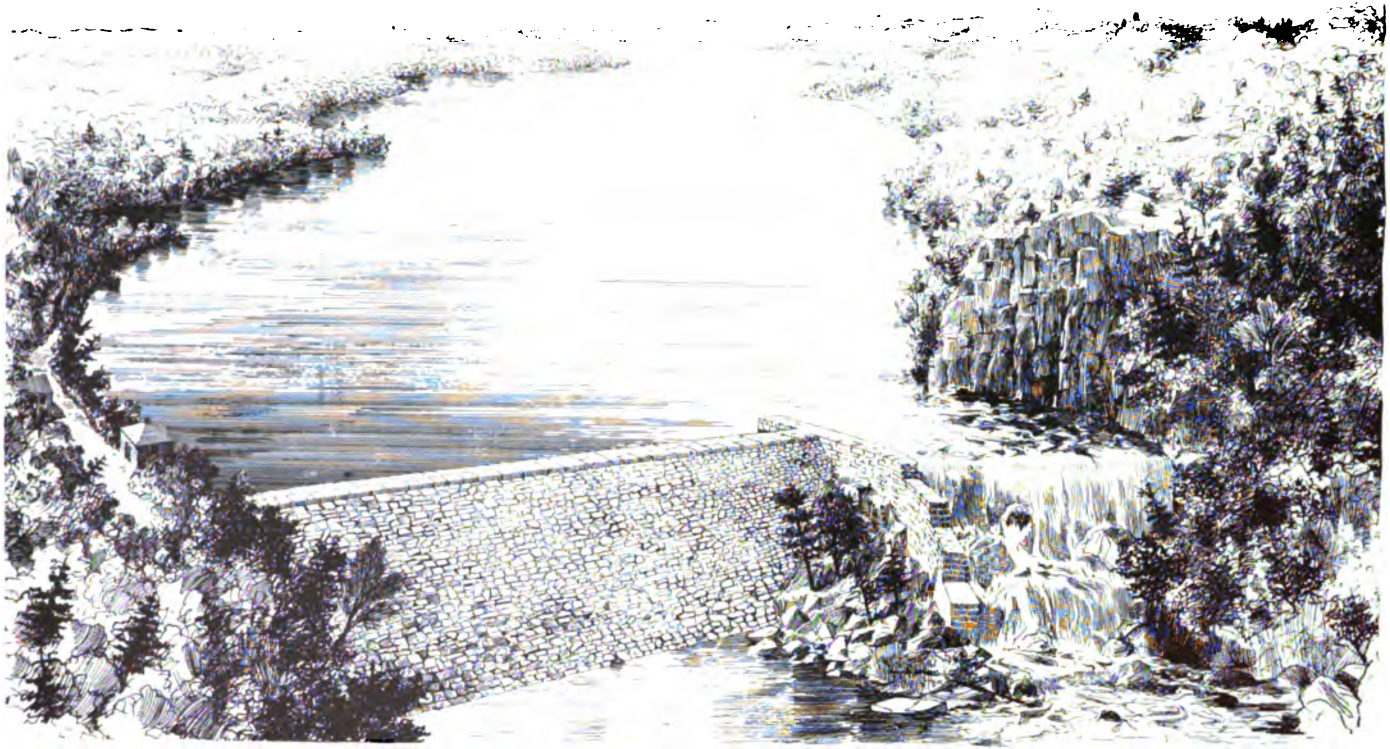

Plate OO. -General View of Proposed Dam at Tumblehead Falls.

This increase in price may be taken as indicating an increase in the value of water for power at Lawrence.

At these prices the Essex Company build and maintain dam and main canals, while wheels, penstocks, etc., are furnished by the lessee.

Unionville, Connecticut.

The water power of the Farmington river at this place is owned by the Union Water Power Company. The total fall is thirty-six feet, used on two levels of eighteen feet fall each. The company sells the land and gives a perpetual lease for water; the price of the latter being $175 per mill power. A mill power is assumed as 7.5 cubic feet of water on eighteen feet head, which gives the gross power per mill power at 15.3 horse power. Hence, we have $11.44 per gross horse power per year, or, with seventy-five per cent. wheel efficiency, $15.26 per net horse power per year.

Birmingham, Connecticut.

The water power of the Housatonic river at this place is owned by the Ousatonic Water Power Company, which leases the water for terms of ninety-nine years. The fall is about twenty-two feet.

The company does not guarantee water, but when the flow of the stream falls below the amount of permanent water leased, all lessees share alike in a reduction. Three grades of water are recognized: (1) Permanent water, for which a rental of $250 per year is paid for one square foot (a square foot of water is established by the leases as five cubic feet per second for twelve hours per day, six days in the week). (2) First surplus water, which is leased at $150 per annum per square foot. (3) Second surplus water, leased at $100 per annum per square foot.

Under twenty-two feet fall the square foot as used at Birmingham is equivalent to 12.5 gross horse power.

The following, taken from the U. S. census report, exhibits the cost of water power under the different classifications and under various efficiencies from sixty to eighty-five per cent.*

Assumed efficiency of wheels per cent.	Corresponding effective horse power of 1 square ft. of water.	Cost per effective horse power.		
		Permanent water.	First surplus.	Second surplus.
60	7,500	$33.33	$20.00	$13.33
65	8,125	30.77	18.46	12.31
70	8,750	28.57	17.14	11.43
75	9,375	26.67	16.00	10.67
80	10,000	25.00	15.00	10.00
85	10,625	23.53	14.12	9.41

First surplus water can be relied upon probably from ten to eleven months in the year, while second surplus water varies considerably from year to year.

The Birmingham development is especially interesting for our case as the price for water is not in any degree included in the price for lands, as at most of the large New England developments.

Oswego, New York.

At this place the first right to the water of the Oswego river is controlled by the State for the use of the Oswego canal. The demand for this purpose is not large and the surplus water is used by two hydraulic canals, one on each side of the river. The power on the east side, not already disposed of, belongs to the Oswego Canal Company, and has an average head of twenty feet. The Varick canal on the west side has an average head of ten to fifteen feet. All water not needed for navigation is divided equally between these two canals.

Water power on the Oswego Canal Company's raceway is considerably more valuable than on the Varick canal, for two reasons:

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* See Tenth Census, Vol. XVI., Water Power, Part I. Rept. on Region Tributary to Long Island Sound. By Dwight Porter, C. E., page 142.

(1) because the head is greater; and (2) because this canal extends to the harbor, thereby giving the advantage of boats coming directly alongside the mills.

For these reasons the rentals charged for water are considerably higher on the Oswego canal than on the Varick. Without going into the detail of the distinctions between first and second water, etc., which have been established, we may refer to the following table from the census report as giving the annual cost of water power on the Oswego canal sufficient for present purposes.

A run is assumed in the table at 11.75 cubic feet per second on twenty feet head, equivalent to 26.7 gross horse power.

Assumed efficiency of wheels per cent	Corresponding effective horse power.	Cost per effective Horse Power.		
		First-class runs, $350 00	Second-class runs, from $250 00 to $300 00.	Surplus runs, at from ½ to ⅔ of first-class.
60	16.02	$21 85	$15 61 to $18 73	$10 92 to $14 57
65	17.35	20 19	14 41 to 17 29	10 08 to 13 45
70	18 69	18 73	13 38 to 16 05	9 37 to 12 49
75	20.02	17 48	12 49 to 14 99	8 74 to 11 65
80	21.36	16 39	11 70 to 15 04	8 19 to 10 93
85	22.69	15 43	11 02 to 13 22	6 72 to 10 29

On the Varick canal a run may be taken at 33.33 cubic feet per second on ten feet head, and yielding 37.9 gross horse power. At seventy-five per cent. efficiency, the cost of water for first-class runs per net horse power is from $8.80 to $10.56 per year.

Cohoes, New York.

The main power at Cohoes formed by the great falls of the Mohawk river is owned by The Cohoes Company. A mill-power costs $200 per annum, and corresponds to six cubic feet of water per second under twenty feet head, or to 13.63 gross horse power. At seventy-five per cent. efficiency, the annual rental for water per net horse power is, therefore, $19.57; at sixty per cent. it is $24.45.

The price of water for power at many other places could be cited, but the foregoing large powers in this immediate vicinity may be considered sufficient for the case.

VALUE OF A GROSS HORSE POWER.

We learn from these figures that the value of water for power varies for a net horse power, on seventy-five per cent. efficiency, from $15.26 to $26.67, when the price is based on permanent power. The mean price of the five large powers considered above is found to be $19.56 per net horse power. For Oswego and Cohoes, the two large powers considered in this State, the figures for seventy-five per cent. efficiency, are $17.48 and $19.57, or a mean of $18.52 per net horse power, whence the mean value per gross horse power becomes $13.89.

As a conservative figure we will use $10.00 per annum as the fair rental value per gross horse power of the water diverted from the river for the use of the Champlain canal; and we will also use this figure in estimating the value of the water power to be created by carrying out the storage project, although it may be remarked that on the Hudson river where the water is all used at first hand in manufacturing, its value to the owners of water powers is really more than this. Ten dollars per annum must therefore be taken as a moderate price to which no objection can fairly be made.

Again, the reasonableness of this price of $10.00 per gross horse power per annum may be still further appreciated by considering that, at the large private company developments which we have just discussed, the dams, head works, raceways, etc., are owned and operated by the companies, and the water is in effect delivered to the manufacturers in their own flumes, ready to be used on the wheels free of all charges except the stated prices. The present case is a parallel one at every power on the river where the developments are already made, except that the manufacturers must maintain their dams, headworks, etc.

With the storage project carried out, it is believed that the difference between $13.89 and $10.00, of $3.89 per gross horse power of permanent power per year, will, as an average, more than provide for these particular items of the fixed charges. For powers which are now undeveloped, but which may be utilized after the construction of this storage, it is considered that the price of $10.00 per gross horse power per annum may still be properly taken, because the market value of water power must inevitably tend to increase in the future — especially on the Hudson river, which, from its nearness to the great commercial centers of the country, must be considered a somewhat favored location. Such increase may therefore be taken to offset the cost of dams, headworks, etc.

VALUE OF THE DIVERTED WATER.

In Table No. 11 we have presented the value of the water diverted at present, as well as the value of the probable future diversion at each of the powers affected from Mechanicville to Glens Falls, inclusive. No account is here taken of the power at the Troy dam, Saratoga dam or the feeder dam at Glens Falls, because, in making these constructions and granting the use of the surplus water, the State has reserved the right to take, at any time, whatever water may be needed to efficiently maintain and operate the Champlain canal.

Referring to Table No. 11, we learn that the water now diverted for the use of the Champlain canal would produce, if used on the several powers at Glens Falls, Sandy Hill, Baker's Falls, Fort Edward, Fort Miller, Stillwater and Mechanicville, a total of 4,683 gross horse power, worth at our assumed price of $10.00 per annum per gross horse power, the sum of $46,830 per year. In the same way we find that the future diversion may be placed at $58,564 per year.

The former of these sums capitalized at five per cent. amounts to $936,600, and the latter to $1,171,280. Taking the difference of $58,564 and $46,830, we have $11,734, which, with its capitalization of $234,680, represents the value of the increase in the diversion due to the proposed enlargement.

TABLE NO. 11: SHOWING THE VALUE OF THE WATER DIVERTED FROM THE HUDSON RIVER FOR THE SUPPLY OF THE CHAMPLAIN CANAL, TO THE OWNERS OF WATER-POWER ON THAT STREAM.

(1.) NAME OF PLACE.	(2.) Working head in feet.	(3.) Present diversion in cu. ft. per second.	(4.) Number of gross horse power.	(5.) Value of one gross horse power.	(6.) Total value of the water diverted.	(7.) Future diversion in cu. ft. per second.	(8.) Value of the future diversion.
Glens Falls	38	419	1,806	$10	$18,060	481	$20,750
Sandy Hill	12	206	280	10	2,800	268	3,630
Baker's Falls	56	206	1.308	10	13,080	268	16,952
Fort Edward	18	206	420	10	4,200	268	5,445
Fort Miller	10	206	233	10	2,330	268	3,025
Stillwater	6	255*	173	10	1,730	351†	2,390
Mechanicville	16	255*	463	10	4,630	351†	6,372
Totals	156	...	4,683	...	$46,830	...	$58,564

* We have here the actual requirement of 175 cubic feet per second plus the permanent diversion to Lake Champlain, or, 175 + 80 = 255 cubic feet per second.

† In this case we have the actual requirement of 247 + 104 = 351 cubic feet per second.

There is, however, one consideration which modifies the totals of these figures somewhat, namely, the fact that at Glens Falls, Baker's Falls and Stillwater the river is not yet developed to its full capacity; and considering the relations which the State, as sovereign, bears to its citizens, there can hardly exist any legitimate reason why the State should pay anything for diverted water which the individual citizen has made no attempt to use. For instance, consider the case at Glens Falls. Here the Glens Falls Paper Mill Company, who own one-half of the flow of the river, have developed their power on the south side of the stream to considerably beyond the minimum flow, and have even been obliged by the exigencies of their business to provide 1,200 horse power of steam, over and above their total development of 6,381 net water horse power. As we learn from column (4) of Table 11, the total value of the diversion at Glens Falls is 1,806 gross horse power, one-half of which is 903 gross horse power, worth at the assumed price of $10.00 per gross horse power, the annual sum of $9,030.

Again, the 903 gross horse power amounts, on seventy-five per cent. efficiency, to 677 net horse power for which steam has been necessarily substituted. But as will be shown in the discussion of the relative value of steam and water power following, steam power costs $40.00 per year more to maintain per net horse power than water. Hence, the Glens Falls Paper Mill Company are subjected to an annual expense of $27,080, in order to maintain steam power, to take the place of the water power diverted from this privilege. At five per cent. capitalization $27,080 amounts to $541,600. It is clear then that an increased diversion from the river is a real hardship on this company.

ONLY PARTIAL DEVELOPMENT AT GLENS FALLS, BAKER'S FALLS AND STILLWATER.

On the other hand, the north side of the river, owned by Finch, Pruyn & Company, is not developed to its full capacity. In no case do Finch, Pruyn and Company's mills on that side utilize more than about sixteen feet head of the thirty-eight feet available. At their sawmill I was gravely informed when I asked why the wheels had not been set to full capacity of the fall, that it was impossible to operate sawmills under more than sixteen feet head, a statement which, if true, would indicate that thus far the modern engineer has mostly lived in vain. Plates J and K show the waste of power at Finch, Pruyn and Company's mill, resulting, we may assume, from their belief in this astonishing fallacy.

A similar waste of power, though on not so large a scale, exists at Baker's Falls, as shown by Plate L.

At Stillwater probably one-half of the summer flow of the river leaks through the dam.

At none of these places, then, can it be justly claimed that the State has yet oppressed the owners of the water power by reason of the diversion for the use of the Champlain canal.* The totals of columns (6) and (8) of Table No. 11, may be therefore taken as indicating the value with full development rather than the existing values of to-day. Deducting then one-half the sum for Glens Falls, and the whole for Baker's Falls and Stillwater from columns (6) and (8) of Table No. 11, and we have remaining $22,990 and $28,837, respectively, which sums may be taken as representing the approximate annual cash value of the water now diverted and to be diverted, while the powers at Glens Falls, Baker's Falls and Stillwater, remain only partially developed.

In the final estimate of the total value of the storage we will, however, use the footings of columns (6) and (8) of Table No. 11 as they stand, without deduction.

TABULATION OF EXISTING WATER POWERS.

Table No. 12 has been prepared as an exhibit of the water power now in use on the Hudson river, and which would be incidentally benefited by the carrying out of the storage project. This table

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* This statement is not intended to apply to the leakage at Glens Falls; nor does it apply to the case of the Glens Falls Paper Mill Company at that place.

is in general self-explanatory, though a brief statement as to its scope may be profitably made. Thus column (6) gives the water required to operate all the wheels now in place at each mill, while column (7) gives the total at each dam. As will be noted, the total at Troy for column (7) is 2,519 cubic feet per second. This statement includes 156 cubic feet for the Green Island electric plant, which has just started. Deducting this 156 cubic feet per second and we have remaining 2,363 cubic feet per second, which may be taken as approximating the permanent requirement at Troy for the last fifteen to twenty years. To prove this we merely note that column (10), in which is exhibited the power actually in use on the Hudson in the fall of 1882 as per Porter's census report, shows a total power at Troy at that time of 1,293 horse power. Deducting from the Troy total of 1,345 horse power in 1895, the 120 horse power credited to the Green Island electric light plant, and there remains a total at the present of 1,225 horse power as per column (9). Taking into account the difference in methods of estimating and it appears clear that the power in use at Troy is practically the same, with the exception of the Green Island plant, as thirteen years ago.

It may be remarked that the agreements between the State and the lessees of the surplus power at Troy are to the effect that in no case shall the water above the Troy dam be drawn below a certain definite level. Whenever that level is exceeded the mills must stop.

It may be also noted that the Troy dam leaks badly, so that the 2,362 cubic feet per second above given is no absolute index of the flow of the stream there.*

Mr. F. W. Orr, of Orrs and Company, paper manufacturers, has kept a record of high water and drought periods since 1876, from which I have prepared by Mr. Orr's permission, Table No. 13, showing the drought periods, etc., as they have been manifested in the river at Troy from 1876 to 1894, inclusive.

The most interesting fact brought out by Table No. 13, is that the year 1891 was not a year of low water at Troy, hence the Mohawk river must have yielded well that year.

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* This leakage may have been at times as much as 1,000 cubic feet per second.

TABLE No. 13: SHOWING LOW WATER PERIODS IN THE HUDSON RIVER AT THE TROY DAM, AS KEPT BY F. W. ORR, ESQ., FROM 1876 TO 1894, INCLUSIVE.

YEAR.	DROUGHT PERIOD.		Length of drought period in days.	Number of days of full power during drought.	Number of days of incomplete power during drought.	Remarks.
	Began.	Ended.				
(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)
1876	Aug. 16	Sept. 18	33			
1877	Sept. 14	Oct. 5	21			
1878						No shortage.
1879	Aug. 11	Aug. 17	6	0	6	
1880	Aug. 13	Oct. 20	68	15	53	
1881	July 19	Oct. 17	59	43	16	
1882	Aug. 5	Nov. 11	98	32	66	
1883	Aug. 10	Sept. 27	48	0	48	
1884	July 22	Oct. 2	72	26	46	
1885						No shortage.
1886	July 9	Sept. 22	75	31	44	
1887						No shortage.
1888	Sept. 7	Sept. 15	8		8	
1889						No shortage.
1890	July 24	Aug. 23	30		30	
1891						No shortage.
1892						No shortage.
1893						No shortage.
1894	Aug. 15	Sept. 12	28		28	

In the foregoing table we have given in column (5) the number of days of full power during the drought period, as defined by columns (2) and (3). This means the number of days in which there was water enough to run all the mills at Troy at full capacity. In the same way column (6) shows the number of days in which the flow of the river was insufficient to run all the Troy mills at full capacity.

At Baker's Falls the total height is fifty-eight feet, of which fifty-six feet are used on the wheels at the Howland Paper Company's mill and fifty-eight feet at Allen Brothers Company's mill. In both cases the water is used from two levels as indicated in column (5). The quantity of 3,306 net horse power in column (11) for Baker's Falls indicates the power which could be developed if 694 cubic feet per second were all used on one head of fifty-six feet. The second race is therefore the source of considerable waste at this power, as at others.

The water powers on the feeder at Sandy Hill have also been included in Table No. 12, as somewhat affected by the proposed storage.

At Glens Falls the Paper Mill Company use a portion of their water on two levels. The quantity of 11,385 net horse power, in column (11), is the total power developable, if the quantity of 3, 521 cubic feet per second of column (7), were all used on thirty-eight feet head. The greater part of the loss here is at the Finch, Pruyn and Company's privilege on the north side of the river.

The Palmer Falls power is also developed on the two-level plan, the fall from the upper race to the lower being fifty feet, and from the lower race to the river, thirty-three feet, giving eighty-three feet working head in all. The upper race is fitted with wasteways, to allow any surplus of water therein to pass over into the lower race. The wheels on the upper race have a rated capacity of 1,212 cubic feet per second, while those on the lower have 2,507 cubic feet per second capacity. The total power actually in use is estimated at 10,500 net horse power, although taking 1,212 cubic feet per second on fifty feet head and 2,507 cubic feet per second on thirty-three feet head we have a total, at seventy-five per cent. efficiency, of 12,198 horse power. Again, computing 2,507 cubic feet per second on eighty-three feet head and we have a possible maximum here, on the basis of the actual development, of 17,700 horse power. Probably, taking into account the speed of wheels and the requirements of power at the various points about the plant, the head races as now arranged are with reference to the actual requirements of power at this mill, although it is apparent from the foregoing that it would be possible under a different system of development to secure considerably more power than at present.

The fact, however, that the plant has grown gradually to meet an increased demand for the manufactured product may be taken into account. Thus, from column (10) of Table No. 12, we learn that only 1,500 net horse power were in use at Palmers Falls in 1882.

The footings of Table No. 12 show that in 1882 the total power on the Hudson river at the points considered was 12,896 net horse power, while in 1895 we have a total of 43,481 net horse power, an increase in thirteen years of 30,585 net horse power. Expressed as a percentage this becomes 237 per cent.

We must conclude, then, that there is a growing demand for water power on the Hudson river.

COST OF STEAM POWER.

On examining Table No. 12, in comparison with the statements of mean and low water flow of the Hudson river as given on pages 116 to 119, and in comparison with the diagrams of daily flow, Plates III. to VI., inclusive, it is at once apparent that the available water power of the several dams now on the Hudson river is already fully developed, except at the one or two points already noted. Indeed, we may say it is somewhat over-developed, although the nature of the manufacturing carried on must be taken into account before deciding. Thus, papermaking, which is the great industry of the Upper Hudson, amounts, according to statistics given in Lockwood's Directory of the Paper and Allied Trades, and in the Paper Trade Journal, to an annual output of from $8,000,000 to $10,000,000. This industry uses immense quantities of wood pulp, a considerable portion of which is ground at the mills using it. The nature of pulp is such that it is practicable to store it for several months without deterioration. It is possible, therefore, to grind pulp during high water and store it up for use in time of low water, and the large development of power, far beyond the low water flow of the stream, which is shown by Table No. 12 to exist at the Saratoga dam, Fort Edward, Glens Falls and Palmer Falls, is merely an exemplification of this practice. Further, for the purpose of driving the papermaking machinery, several of the mills now use steam as auxiliary to the water power.

At Fort Edward the Glens Falls Paper Mill Company use 2,900 horse power of steam which would be partly changed to water power if there were water enough to furnish this additional power. In the same company's mill at Glens Falls, there are 1,200 horse power of steam which could also be largely changed to water power if it were available.

Under this head it may be further pointed out that the whole paper industry at the present time depends upon the use of water for power. If by any chance it should become necessary to use steam power to the entire exclusion of water, the price of the manufactured product would certainly materially advance, for the simple reason that paper can not be made at the present prices on a steam power basis. To illustrate this saliently it may be mentioned that the power required to grind a ton of dry pulp in twenty-four hours varies, according to the quality of the pulp produced, from sixty to eighty net horse power.

Probably the best experience comparison of the relative cost of steam versus water power to be obtained anywhere is derived from the records of the Philadelphia Water Department, as published in the annual reports of that department from year to year. The city of Philadelphia has, at the Fairmount pumping station, a water power plant of from 500 to 600 net horse power, while the several steam plants of the city aggregate about 6,000 net horse power. Both classes of plants have been kept for several years in good order, are efficiently managed and the records carefully made. For the years 1887 to 1894, inclusive, the statistics show the annual cost of producing one continuous net horse power by water, including labor, fuel, supplies and repairs, at $24.60. In the same way the cost of steam power for the years 1887 to 1893 inclusive, for the entire plant, is shown to be $78.53. In neither case do these figures include either the capitalization of first cost and depreciation, or the annual cost of taxes and insurance. We have, then, for the figures as they actually stand:

Annual cost of steam power per net horse power......	$78 53
Annual cost of water power per net horse power......	24 60
Difference..................................	$53 93

Some of the steam pumping stations are away from water or railway transportation, thereby necessitating drayage of coal, which causes a range in price from $1.89 per ton for the commoner grades, to $3.09 for the higher grades.

Generally, the conditions at Philadelphia are favorable to low cost of steam power. At most places the cost per net horse power per year will be greater than shown by these figures.*

It is clear, then, why steam power can not be substituted for water, except at large additional cost of the manufactured product.

Dr. Chas. E. Emery, of New York, who has studied the cost of complete installation of steam plants as well as the annual cost of operating them, more carefully than any other American engineer, has given, in a recent paper, the comparative cost of developing steam power in blocks of 500 net horse power, with several of the different kinds of engines now in general use.† Table No. 14, from his paper before the American Institute of Electrical Engineers, is so pertinent to the present discussion that it is reproduced here. This table shows somewhat lower annual costs per net horse power than indicated by the Philadelphia experience. In considering why this is so we may take into account two factors:

(1.) The Philadelphia plant is a municipal plant and probably, even though well managed, the labor account is higher than it would be for a private manufacturing enterprise conducted on a strictly business basis.

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* See Mr. Vermeule's Report on the Water Supply and Water Power of New Jersey, page 322.

† The Cost of Steam Power Produced with Engines of Different Types under Practical Conditions, with Supplement Relating to Water Power. By Chas. E. Emery, Ph. D. In the Electrical Engineer, Vol. XV. pp. 316 and 341 (March 22 and April 5, 1893).

(2.) Dr. Emery's table is based upon the very best engine practice of to-day, and while the several items have been derived from experience, still it is probable that in the great majority of cases the annual costs in actual practice would be somewhat greater than he has indicated. With these modifying elements in mind we may make the following deductions from Table No. 14, for the classes of engines in more common use, as pertinent to our present case.

(1.) With simple high speed, non-condensing engines, the total cost per net horse power of installing a 500 horse power plant, including engines, boilers and necessary buildings, all erected ready for operation, and also including cost of inspection and loss of interest during construction is found to be $63.91. With coal at $3.00 per gross ton, of 2,240 pounds, delivered in front of the boiler, and including the cost of all labor, oil, waste, ordinary repairs, insurance, taxes, renewals, and dividends, the annual cost of operating such an engine ten hours a day for 308 days is found to be $36.17 per net horse power.

When operated twenty hours per day for 365 days, the annual cost is found to be, with coal, as before, $70.89 per net horse power.

With coal at $4.00 per gross ton, the costs are, for ten hours per day for 308 days, $42.54; and for twenty hours per day for 365 days, $85.29.

(2.) With simple low speed non-condensing engines the cost of installing 500 net horse power plant (all conditions as in (1) preceding), is found to be $68.19 per net horse power.

With coal at $3.00 per gross ton the cost of operation for ten hours a day for 308 days is $34.20 per net horse power; and for twenty hours per day for 365 days, $65.55.

With coal at $4.00, the costs are $39.94 and $78.53 respectively.

(3.) With simple high speed condensing engines (all conditions as in (1) preceding), the cost of installing a 500 net horse power plant is $54.71 per net horse power.

With coal at $3.00 per gross ton the cost of operating such an engine ten hours a day for 308 days is $27.49 per net horse power, and for twenty hours per day, for 365 days, the cost is $52.82.

With coal at $4.00 the costs are $31.73 and $62.42, respectively.

(4.) With simple low speed condensing engines (all conditions as in (1) preceding), the cost of installing a 500 net horse power plant is $59.51 per net horse power.

With coal at $3.00 per gross ton, the cost of operating such an engine ten hours a day for 308 days will be $26.77 per net horse power, and for twenty hours per day, for 365 days, the cost is $50.25.

With coal at $4.00 the costs are $30.73 and $59.20, respectively.

(5.) With compound high speed condensing engines (all conditions as in (1) preceding), the cost of installing a 500 net horse power plant is $56.14 per net horse power.

With coal at $3.00 per gross ton, the cost of operating such an engine ten hours a day, for 308 days, will be $26.36 per net horse power, and for twenty hours per day for 365 days, $49.99.

With coal at $4.00, the costs are $30.22 and $58.72, respectively.

(6.) With compound low speed condensing engines (all conditions as in (1) preceding), the cost of installing a 500 net horse power plant is $60.35 per net horse power.

With coal at $3.00 per gross ton the cost of operating such an engine ten hours a day for 308 days, will be $25.53 per net horse power; and for twenty hours per day, for 365 days, $47.27 per net horse power.

With coal at $4.00 the costs will be $29.09 and $55.33 respectively.

The cost of steam coal for Hudson river points, depending on the grade, ranges from $2.40 per ton to $3.30.

The most of the manufacturing establishments on the Hudson river operate twenty-four hours per day, for 308 days in the year, or 144 hours per week, as against 140 hours in the second portion of Dr. Emery's table. This will increase the fuel, oil and waste accounts by nearly three per cent. When running twenty-four hours a day it becomes necessary to work the labor in three shifts of eight hours each, instead of two of ten hours each, which adds to the cost of that item, say twenty per cent.

We have then, a series of costs per net horse power per annum for 500 net horse power steam plants applying to the exigencies of the service required on the Hudson river, namely, operated twenty-four hours a day for 308 days, as follows:

Simple high speed non-condensing engines of 500 net horse power capacity when operated 24 hours a day for 308 days, and with coal at $3.00 per gross ton, a cost per net horse power of	$74 67
For simple low speed non-condensing engines	69 03
For simple high speed condensing engines	55 80
For simple low speed condensing engines	52 98
For compound high speed condensing engines	52 70
For compound low speed condensing engines	49 83
Mean	$59 17

As already stated, the foregoing figures represent the possibilities of the very best practice of steam engineering of to-day; and since very few plants are operated as cheaply as these figures indicate, we may conclude that the figures derived from actual experience on a large scale in Philadelphia are not far from right. Though we may note that the Philadelphia figures include, in addition to the repairs of the power plants the cost of the repairs, etc., of the pumping plants, which may, however, be considered the same in either case. Taking into account everything, we may say that the cost of one net horse power per year produced by water power is, on the Hudson river, at least $40 cheaper than one net horse power produced there by steam.

But $40 capitalized at five per cent., the rate at which money can be borrowed for individual enterprises, is $800, and adding thereto the original cost of one net horse power of our assumed 500 horse power steam plant and we have a total of say $860, which amount, per net horse power, may be profitably expended in developing a 500 net horse power water plant before the water power becomes as expensive as the steam power. At this rate w may expend $430,000 on a 500 net horse power plant and still n exceed the capitalized cost of steam power, even though the fir cost of the steam plant itself did not exceed about $30,000.

The foregoing figures are perhaps sufficiently suggestive, eve when applied to a small 500 horse power plant; but if we appl them to a power like that at Palmers Falls, they become eno mous.

Referring to Table No. 12 we learn that the actual developmen there is now 10,500 horse power. With the river regulated to minimum flow of not less than 3,300 cubic feet per second at tha point, it will be possible to develop on Palmers Falls, 23,300 continuous, net horse power. At $40 per year saving over steam power, we have an annual saving of $932,000.

As further showing the immense possibilities of rational river regulation and its value in comparison with the use of steam power, it may be pointed out that in order to develop 23,300 horse power at Palmers Falls we may expend $20,038,000 before the water power there would become as expensive as steam power.

Moreover, Palmers Falls is so favored by natural conditions that the present development probably has not cost for the water power plant, more than $70 to $80 per net horse power; and if it were desired to develop 23,300 continuous net horse power there, it could be accomplished for probably about $60 per horse power.

On again referring to Table No. 12, we learn that the total head now actually in use on the Hudson river and its branches that would be affected by the proposed storage, may be taken at 348 feet. There is also between Palmers Falls and Troy at least 168 feet which is still entirely undeveloped. We have then a total utilizable fall on the river from Troy to Warrensburg of 516 feet. We also have on the main river between Thurman and North River village, a total developable fall, as per Plate VII., of 450 feet.

According to Table No. 12, the power now actually in use is 43,481 horse power, which if it could all be used continuously, would represent an annual saving over steam of $1,739,240.

Again, let us assume that the proposed regulating works will

insure at least 3,300 cubic feet per second * on the entire 516 feet fall. We have, then, a total of 145,320 net horse power as the possible development under the conditions assumed, and this again represents an annual saving as against steam power of $5,812,800.

If we take into account the 450 feet fall above Thurman, on which we may expect a permanent flow of at least 750 cubic feet per second, we have a total possible development of 28,700 net horse power, which has a value over and above steam of $1,148,000.

Taking the sum of 145,320 and 28,700 and we have a possible total on the regulated river of 174,020 net horse power. And this too, it must be understood, is permanent power — good for continuous operation, if required, for all time for 365 days in the year.

Again referring to Table No. 12, we learn that the present total development on the Hudson river is 43,481 net horse power, of which as we have seen a considerable proportion is only available for part of the year. Without spending time to determine the exact figure, we will say that the present developed permanent power of the river—that which may be used continuously every day — does not exceed 30,000 horse power; while for the entire unregulated stream the total possible continuous power will not exceed 60,000 net horse power.

The result of the regulation therefore is to increase the permanent power from 60,000 net horse power to 174,020 net horse power, a gain of 114,020 net horse power, or, what is the same thing, a gain of 152,076 gross horse power. At $10.00 per gross horse power per year this gain would represent, then, an annual value of $1,520,760, and this sum, capitalized at five per cent., represents an investment of $30,415,200, which, if it were certain the vast power so created could all be utilized in a few years, could be expended in constructing this storage for the benefit of the water power alone, without exceeding the reasonable commercial limits of this specific case.

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* This is an average figure merely for the whole power from Troy to Warrensburg. As we have stated in discussing, on page 124, the possible development of permanent water power at the Hadley reservoir, for the upper reaches of the stream the permanent flow would be much less than 3,300 cubic feet per second.

At any rate we may conclude that the small per cent. of this total of $30,415,200, which we shall show further on as necessary to secure the substantial benefits to the various interests on the Hudson river, may be profitably expended at an early date.

Much has been said of late years of the development of cheap water power on the Niagara river at Niagara Falls, and public attention has been largely directed to that place to the exclusion of the possibilities of other streams.

As we have seen, the cost of developing water power will vary greatly with the conditions at different places, and while the figures are not at hand for determining the cost per net horse power at Niagara Falls, still it can not be very much less than on the Hudson; and taking into account the advantage of the Hudson in proximity to the great eastern markets, as well as the river transportation thereto, it is believed that the advantage on the whole account lies slightly with the Hudson river.

On page 159 we have shown that, if necessary, we may expend in development $860 per net horse power before water power will become as expensive as steam power. Let us now examine as to the actual cost of developing large water powers.

COST OF WATER POWER DEVELOPMENT.

Referring to the paper by Dr. Emery, which we have already quoted, it is learned that the development of water power on the Merrimack river has cost about $142 per net horse power; but on the Hudson, where the conditions are generally very favorable, the cost is much less, usually so far as definite figures can be obtained not exceeding $100 per net horse power; and many of the developments on the Hudson which are, however, of a somewhat unsubstantial character, have been made for far less than this figure. For permanent construction, and reasonably large blocks of power developed, we may, however, consider $70 to $100 per net horse power as fair estimate figures. The possibilities at Palmers Falls have been discussed on page 160.*

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* On cost of water power development see Dr. Emery's paper on Cost of Steam Power, etc., already referred to.

NEGLECT OF WATER POWER POSSIBILITIES IN THIS STATE.

When one studies the question of water power versus steam power in detail, among the many points of interest presented none is more prominent than the relative neglect of water power which has existed particularly in this State.

Our nearness to the Pennsylvania coal fields has, to some extent, led to this neglect, although the main cause must be ascribed to a lack of definite views on the part of manufacturers as to the relative costs of the two kinds of power. Moreover, the vast amounts of capital invested in the manufacture of steam boilers and engines in comparison with that invested in the manufacture of turbine water wheels has given the question a commercial bias, in which the constant reiteration of the low cost of steam power has, possibly, in the absence of sharp analyses of relative costs, affected the judgment of the interested parties. Considering the proximity of the Hudson river water power to the great markets of the country, it is difficult to understand its comparative neglect on any other basis.

As regards the State at large, the policy of conserving the internal navigation even at the expense of the manufacturing interests must be credited with assisting to maintain the general lack of appreciation of the value of water power. The absence of a Mill Act and the influence of such laws in fostering the manufacturing interests will be referred to at length further on.

IMPROVEMENT OF NAVIGATION IN THE HUDSON RIVER BETWEEN NEW BALTIMORE AND TROY.

This part of our subject has been so thoroughly discussed in the various reports of the United States government engineers, and also in several of the annual reports of the State Engineer and Surveyor, that I shall go no farther here than to indicate the lines on which the improvement now in process has been carried out, and the probable effect on the river of such increase of the dry weather flow as may be expected to result from the construction of the proposed system of reservoirs.*

From a few miles below New Baltimore there has never been until recently any trouble on account of lack of water for navigation purposes; the work of improvement has therefore been mostly confined to that section of the river extending from New Baltimore to Troy, a distance of about twenty miles. This work has been carried on more or less continuously since 1797, in which year the first State appropriation was made. Before 1831, the work was carried on under State appropriations and contributions from the cities of Albany and Troy, but in that year the jurisdiction of the Federal government over these waters was confirmed by judicial decision.

Since 1831 the work has been carried on by both the State and Federal governments. The last State appropriation was in 1892.

Previous to 1866 the work was of somewhat unsatisfactory character, owing to its being done largely without any comprehensive plan of operation, as well as irregularly.† Some increase in depth of channel was, however, effected, as may be gathered from the statements of depth at several points following.

The plan of improvement followed since 1867 was devised by General Newton on the principle that, in a tidal estuary receiving a moderate inflow of fresh water at its head, an increased depth of water is best secured by increasing the tidal scour.

According to General Newton, in his annual report to the Chief of Engineers for 1875, the action of the flood tides is to form deposits of whatever detritus may be carried in suspension, while the ebb tides tend to scour such deposits away. Under such action the inclination of the bed of a stream increases towards the head until the two forces are in equilibrium; when this point is reached the slope of the bed and the depths become constant.

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* For information in regard to the Hudson river see the several indexes to the Reports of the Chief of Engineers, where numerous references to nearly every phase of the subject may be found.

Also see reports on Hudson river improvement in the Annual Reports of the State Engineer from 1867 to 1892, inclusive.

† For complete detail in condensed form of the various steps in the Hudson river improvement down to 1862, see a communication from the State Engineer and Surveyor in answer to a resolution of the Senate, in Senate Document No. 86, 1863.

The erection of the Troy dam has had the same effect in decreasing the scour of the ebb as would result from natural causes somewhat higher up if the dam had not been built, or, if the dam had been built higher up, the deposits would form above the present position, with the result of an increase in the scouring action of the ebb in front of the city of Troy. It may be concluded, then, that the location of the Troy dam below the head of original tidal influence is in some degree responsible for the difficulty in maintaining a channel between Albany and Troy.*

General Newton's plan, as adopted in 1867, provided for securing a navigable channel eleven feet deep at mean low water from New Baltimore to Albany, and nine feet deep at mean low water from Albany to Troy. This work has been carried out along the following lines:

(1) A system of longitudinal dikes to confine the current sufficiently to allow the ebb and flow of the tidal current to keep the channel clear. These dikes to be gradually brought nearer together from New Baltimore towards Troy, so as to assist the entrance of the flood current and increase its height, their height to be kept approximately at the level of the tidal high water, so as not to confine the freshets, the exact level, however, being left to be determined as the work progresses.

(2) That the dredge be used so far as necessary, to open the channels above described, which the current should not be allowed to do, except very gradually, lest accumulations dangerous to navigation be formed below.

(3) Keeping, as far as practicable, the side reservoirs open to the passage of tidal currents by gaps at their lower extremities in order to increase the tidal flow.

(4) Dumping all dredged material in secure places, where it cannot be moved back again into the channel by the current.

(5) Constructing the dikes of timber and stone in a manner to secure their permanency at a minimum cost, the details, varying with the locality, to be left to the discretion of the local engineer,

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* See report of Lieut.-Col. John Newton, Corps of Engineers, for the fiscal year ending June 30, 1875. In Annual Report of Chief of Engineers, 1875, Pt. II., p. 196.

to be so designed as to admit of having an increased height given to the dikes if necessary.

(6) To protect, when necessary, the banks and islands against the abrading action of the currents by revetments.

(7) That limits, beyond which no encroachment upon the channel should be made, be prescribed, and that any such encroachments be reported to the engineer in charge.

This improvement was substantially completed on June 30, 1892, the total expenditure thereon by the Federal government amounting to $1,247,940.29.

July 13, 1892, Congress sanctioned another project, which provides for maintaining old improvements and constructing new regulating works for eight miles below New Baltimore, and also deepening the entire reach so as to afford a channel 400 feet wide and 12 feet deep, from Coxsackie to the foot of Broadway, Troy, and from thence 300 feet wide and 12 feet deep to the State dam. A sum not to exceed $2,447,906, in the aggregate, was appropriated for this work.

From 1797 to 1892, inclusive, the State of New York appropriated for work on the Hudson river the sum of $1,504,429.29. Between 1825 and 1867 the city of Troy contributed $127,248.59, and the city of Albany $5,566.66; a total contribution for the two cities of $132,815.25. The total amount expended and appropriated for Hudson river improvement from 1797 to date is therefore $5,333,090.83.

The results obtained by this expenditure are exhibited by the following:

In 1819 the available channel depth between New Baltimore and Albany was four feet at low water; in 1867 it had increased to 7.5 feet; in 1879 to 8.5 feet; in 1885 to 10 feet, and in 1892, to nearly 11 feet.*

Early in the present century the tidal rise in this section of the Hudson river was 1.2 feet at Troy, 2.3 feet at Albany, and 3.7 feet at New Baltimore. At the present time the tidal observations show, at the Troy dam 0.8 feet, at the steel works 2 feet, at Albany 2.5 feet, at Castleton 2.6 feet, at Coeymans 3 feet, and at New Baltimore 3.4 feet.

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* A table showing the depth from 1819 to 1879 may be found in the Annual Report of the Chief of Engineers, 1885, p. 691.

The mean rise in New York harbor is 4.4 feet.

The plane of mean low water at New York is below that at Troy dam, 4.1 feet, below that of the steel works 2.5 feet, below Albany 2 feet, Castleton 1.6 feet, and below New Baltimore 0.8 feet.

In the same way the plane of mean high water at New York is above that of the Troy dam + 0.52 feet, the steel works + 0.12 feet, Albany —0.06 feet, Castleton —0.25 feet, and New Baltimore —0.17 feet.

Comparing these figures as to tidal planes at the several points and it is at once apparent that the surface slope of the stream is considerably less in the regulated section at time of high water than at low water.

For instance, the fall from Troy dam to New Baltimore at low water is 3.3 feet, while at high water as a mean it is 0.7 feet. Further, this is not uniformly distributed, as we see that between Albany and New Baltimore the high water surface slope is only 0.11 feet; between Albany and the steel works it is also only 0.18 feet, leaving 0.4 feet between the steel works and the Troy dam.

It is clear, then, that the movement of the ebb flow in the channel must at the beginning be very slow and any practicable method of increasing the high water slope is worthy of very serious consideration. But before examining that phase of the question let us consider the theory of the present improvement one step farther.

In arriving at the plan of systematic improvement carried out since 1867, it was assumed that the minimum fresh water flow of the Hudson river was as low as about 2,000 cubic feet per second for a considerable portion of each year. On this point the eight-year gagings, which we have tabulated and diagramed, furnish definite information which was not available in 1867, and which, or course, could not be available until after the lapse of the several years required to make such a series. It is sufficient to say then that the gagings establish the fact that usually the summer flow at Troy is considerably greater than 2,000 cubic feet per second. Indeed, it will be only in an extreme case that it runs as low as that for short periods.

The gagings also show that freshets of from 80,000 to 100,000 cubic feet per second may be expected. While such flows continue they give ample volume and velocity for scouring away deposits in the head of the river which have been made in previous periods of low water. Their good office in this particular is, however, more than balanced by their tendency to wear away the banks and islands, transporting sand, gravel and mud to form obstructions lower down. The floods must therefore be considered as something of a menace to the integrity of the regulating works, however well constructed, for even though the exposed banks and heads of islands are protected by revetments, still the flood flows will inevitably transport from the higher reaches of the river a vast quantity of detritus to be dropped somewhere in the tidal portion. It is fundamentally true, therefore, that river regulation, wherever it is possible to do so, should also proceed on the line of decreasing the flood flows, as a means of protecting the tidal portions from the inevitable filling up somewhere which otherwise must certainly occur.

It is not intended in the foregoing discussion to intimate that the plan worked upon since 1867 is not on the whole the best that can be desired for the peculiar circumstances of the Hudson river. On the contrary, it is believed to be in every way suited to the conditions of this river. We merely need to go one step farther. The effect of the dikes already constructed is to confine the summer flows to a channel much narrower than the original, and which are high enough to permit of considerable increase in the summer flow before the water would rise above them, and overflow into the broad areas at the sides.

An increase in depth may therefore be accomplished by so regulating the flow of the river, by impounding reservoirs, as to give a larger summer fresh water flow than we now have. By this means it is further quite possible to so far modify the flood flows as to materially decrease the amount of detritus and alluvial deposits in the tidal section. The cost, therefore, of maintaining a channel in the future will be materially decreased by such procedure.

It appears then that an artificial increase in the summer fresh water flow of the stream would be a benefit in three particulars: (1) by increasing the depth; (2) by increasing the surface slope of high water, thereby increasing the velocity and consequent scouring action of the ebb flow, and (3) by decreasing the floods and their prejudicial eroding and transporting action.

By courtesy of Col. George L. Gillespie, of the Corps of Engineers, I have been furnished with the daily tide record as kept by the United States engineers at Albany for the navigation season of 1894 and 1895. And in order to place this whole question of the relation of the fresh water inflow of the stream to the tides on a rational basis, I have platted the daily tide records on the diagram of daily flow of the stream at Mechanicville for those years. (Plate VI.)

A study of this diagram shows that whenever the river rose to a flow of from 4,000 to 5,000 cubic feet per second at Mechanicville, there was an increase in the height of both the flood and ebb tides at Albany of about 1.5 feet. Hence the mean depth of water was increased by that amount. To this proposition there is almost no exception during the two years for which we have the reliable record of tides. It follows then with absolute certainty that such regulation of the flow of the fresh water portion of the stream, by impounding reservoirs, as will insure not less than 4,500 cubic feet per second at Mechanicville will of itself alone under existing arrangements increase the mean depth of water at Albany about 1.5 feet.

In this place it may be pointed out that taking into account the difference in tributary drainage areas we will then have in the river at Troy where we are below the Mohawk, which by itself has a drainage of 3,400 square miles, an actual ordinary summer flow of nearly 6,000 cubic feet per second. On this point see the discussion on pages 113-114.

It will be noticed, too, that the difference in elevation between high and low water is quite as marked when we have 4,500 cubic feet at Mechanicville as when the river is near the minimum stage. Hence with the large increase in volume resulting from the increased inflow the scour must be correspondingly greater at such times, while the larger inflow must further tend to maintain the slope during the entire period of ebb flow.

Moreover, these considerable advantages of increased inflow are gained without in any degree approximating to the limit where destructive flood action begins.

This part of our subject could be pursued at much greater length without exhausting it, but the foregoing is sufficient for the purposes of this preliminary report.

In order to show the possible disturbing effect of winds and the lunar periods on the tides, these two elements have also been platted on Plate VI.

We will now briefly point out the value of the Hudson river as a means of communication.

According to statistics collected in 1890 by Chas. G. Weir, assistant engineer, and published in the annual report of the Chief of Engineers for 1890, it appears that in 1889 the total tonnage of the local traffic on the Hudson river was 15,033,309 tons, and the value of the same was $378,196,094. These figures do not include the freight coming to and leaving tidewater through the State canals, which amounted to 3,592,437 tons more, representing a value of $108,000,000. We have then for both classes of traffic a grand total of 18,582,596 tons, valued at the enormous sum of $485,733,094. In addition 5,000,000 passengers were carried on the river that year.

Referring to the statements of depth of water on page 166, it appears that in 1867, at the beginning of the systematic improvement, there was a mean low water depth of 7.5 feet. The present improvement, when completed, will give 12 feet to the Troy dam. The cost of obtaining the increase in depth from 7.5 to 12 feet, or 4.5 feet, will be the sum of the expenditures by the Federal and New York State governments from 1867 to the completion of the present project, or $4,468,846.29, of which the State has paid

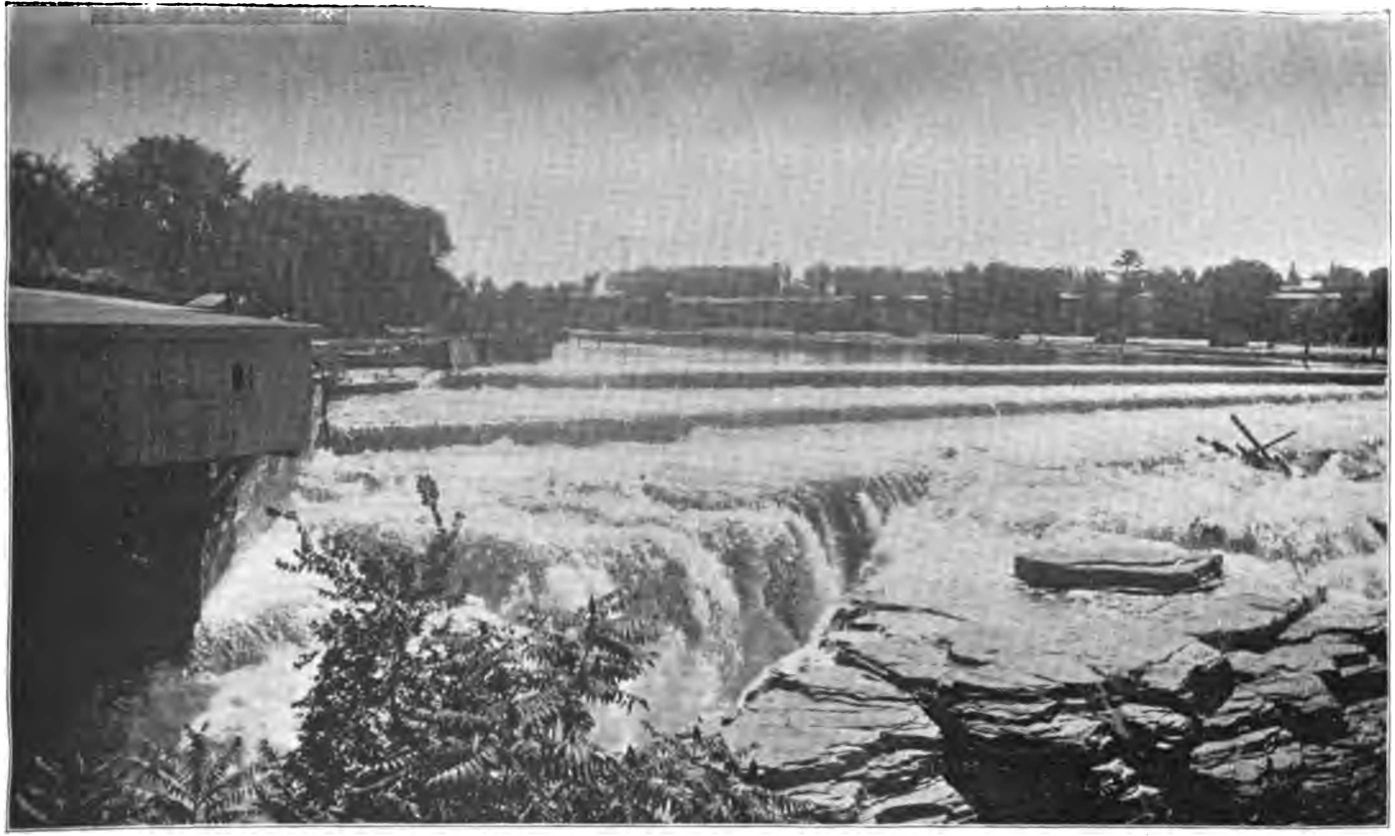


PLATE P.—VIEW OF THE SECOND OR SURPLUS WATER DAM AT GLENS FALLS.

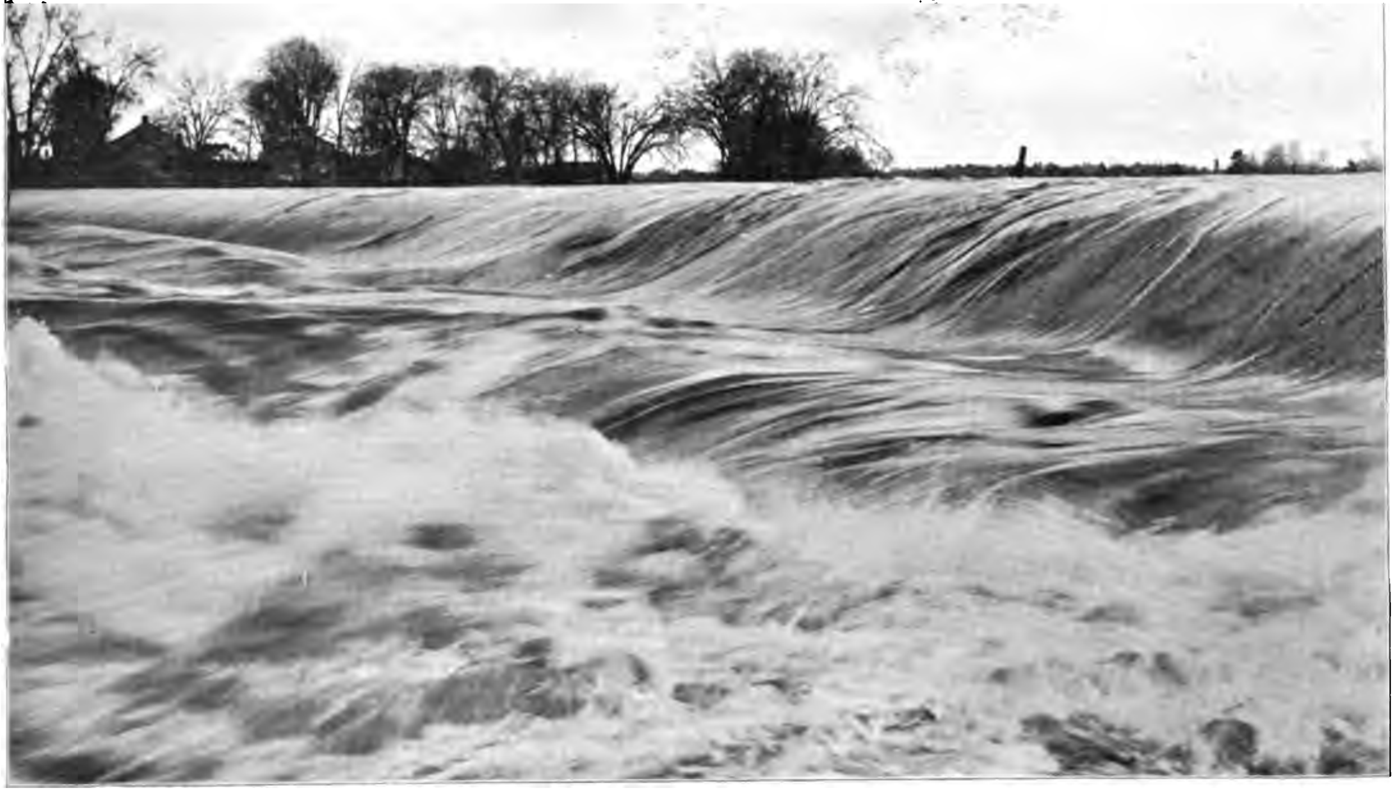


PLATE Q.—HIGH WATER AT GLENS FALLS.

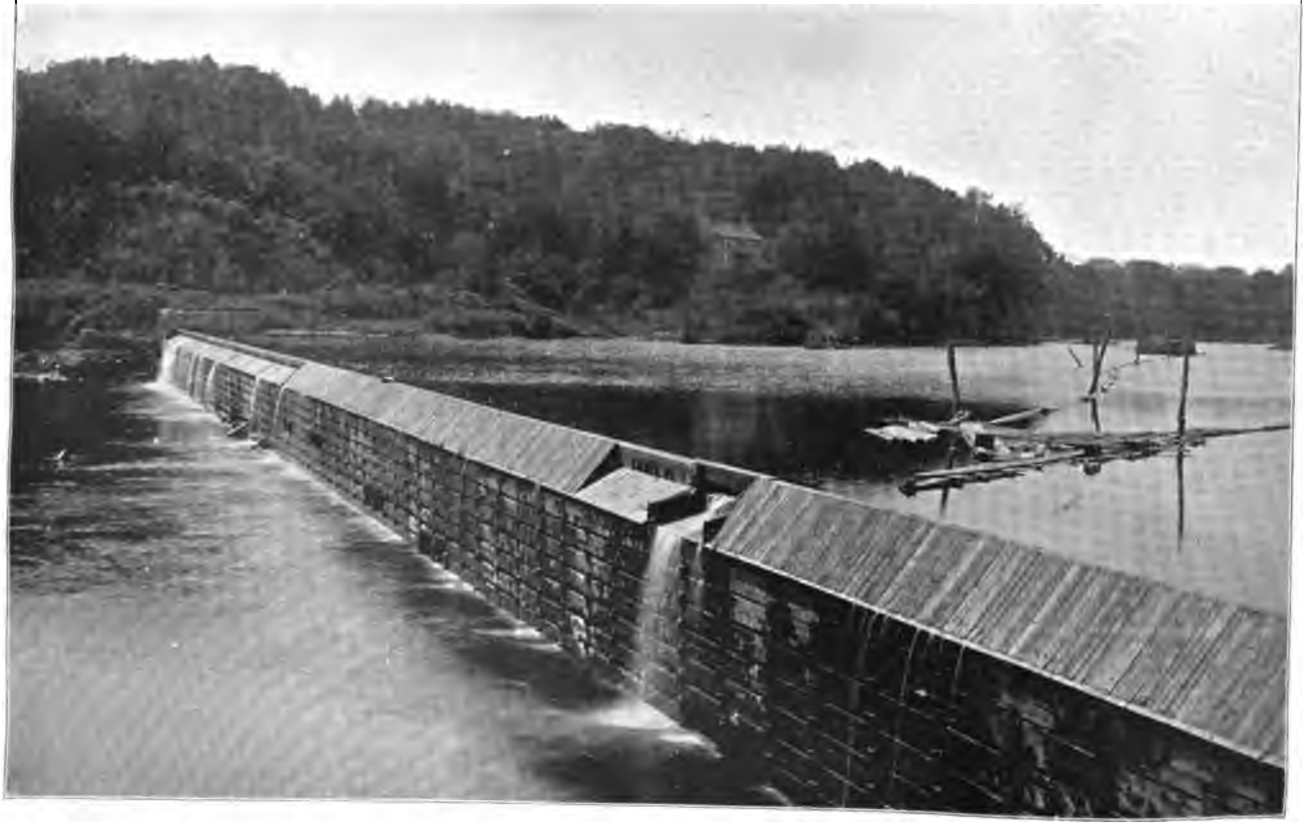
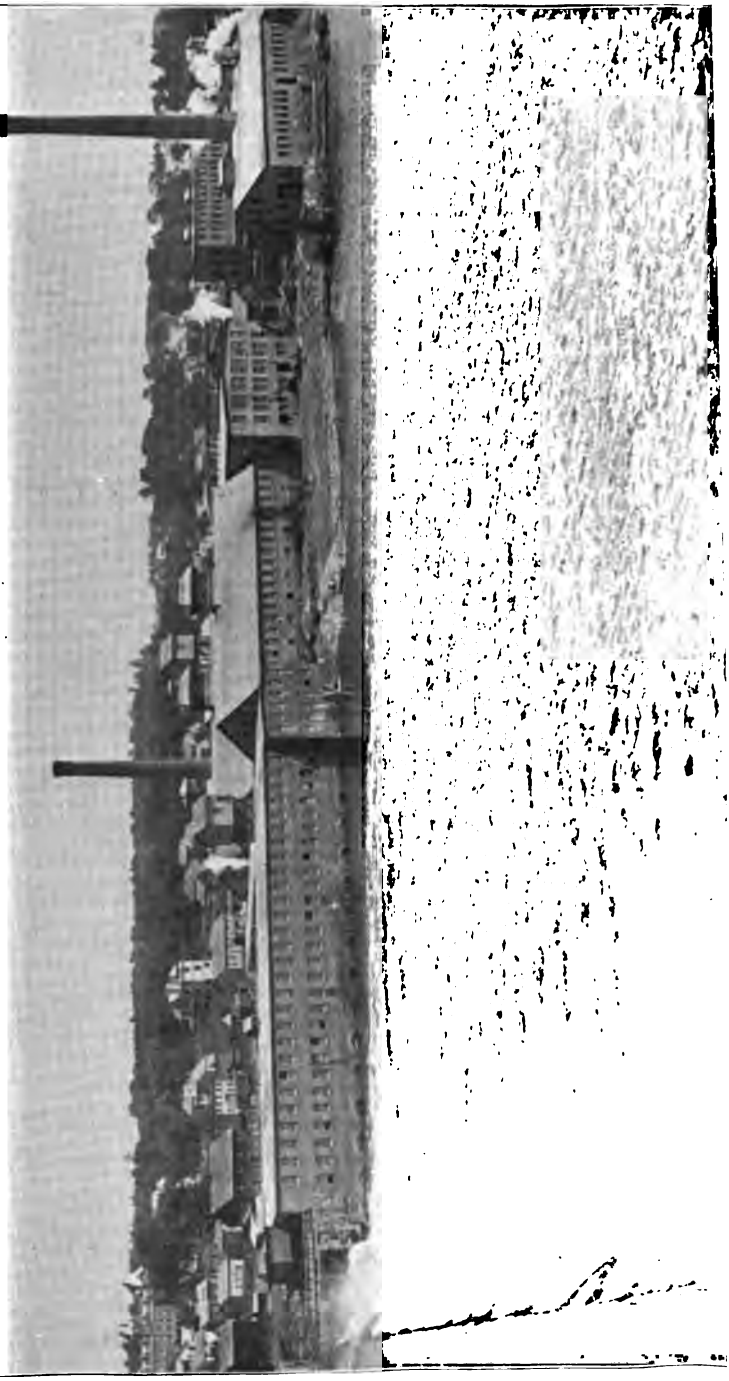


PLATE R.—PRESENT DAM AT FORT EDWARD.



$733,000, that being the sum of the State appropriations made from 1867 to 1892, inclusive. It follows then that the actual cost of an increase in depth of one foot and the maintaining of the same, may be taken, without reckoning in the interest account, at about $1,000,000. Reasoning in an offhand way, we may say, therefore, that the 1.5 feet in depth which may be gained by increasing the summer flow of the stream to not less than 4,500 cubic feet per second at Mechanicville is worth about $1,500,000.

Again, the commercial statistics lead to another thought of some interest at this time, when in whatever direction one turns there is a demand for a decrease in the cost of water transportation by an increase of depth of water, which in its turn leads to an increase in capacity of boats, namely, provided the additional depth of 1.5 feet were to result in a decrease in cost of transportation on the Hudson of an average of only two cents a ton, the yearly saving would amount to $371,652.92; or at one cent per ton, the amount still would be $185,825.96. The capitalization of the former of these sums at five per cent. is $5,433,048, and of the latter $2,716,524.

To show that a reduction of two cents per ton is quite within the probabilities we have merely to consider that $371,652.92, the annual saving effected by such reduction, is only one-thirteenth of one per cent. of $485,733,094, the value of the freight carried in one year.

THE CASH VALUE OF THE PROPOSED STORAGE.

We have seen on page 161, that the value of the proposed storage to the water-power of the stream, not including the possible power development at the Hadley and Conklinville reservoirs, may be taken ultimately at $30,415,200, while the value to the navigation interests may be taken at from $2,716,524 to $5,433,048.

The water to be used by the Champlain canal in the future is shown by the deductions from Table No. 11, to have an estimated value, when used for producing power, of $1,171,280; and finally the additional power to be developed at Hadley reservoir is estimated at $1,000,000. The sum of these several items, using $5,433,048 as the value to navigation in the lower river, is $38,019,528. If it is objected that these estimates are too large, we may divide them by two, and still there remains the total capitalization of $19,009,764.*

As to the significance of these large totals it may be stated that the object is not to present to the Legislature at the present time final figures, but merely to exhibit saliently (1) the relations which rational regulation of the Hudson river may bear to the symmetrical development of the whole region; and (2) to point out how seriously a mistaken State policy may stand in the way of such symmetrical development.

COST OF THE RESERVOIR SYSTEM.

We will now show briefly that these vast benefits may be secured by an investment of about $2,600,000.

As stated at the beginning of this report, the data is not yet at hand for a complete estimate of cost of the whole reservoir system, outlined on pages 93-5. Enough is known, however, to enable us to approximate the total cost sufficient for present purposes. We have at hand, as the result of this season's work, fairly complete information in regard to the proposed system in the Schroon river valley, the proposed Indian and Piseco lake reservoirs, together with the proposed reservoirs at the Boreas ponds and at the so-called Cheney pond on the Boreas river. An approximate estimate may also be made of the proposed Hadley reservoir.

Having estimated the cost of these several reservoirs as well as the volume of storage developed, we can then establish a price per million cubic feet stored, which may be applied without material error to the balance of the system, where the conditions are essentially the same.

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* These total sums do not include the value of the water power which could be developed at Conklinville for the reason that the cost of the reservoir there is not included in the estimates as stated on page 96.

Schroon Valley System of Small Reservoirs.

This system comprises the list of lakes and ponds given on page 95, except that Paradox lake and Valentine pond are included in the Schroon lake reservoir. Table No. 15 gives the details of the estimates as prepared.

Referring to Table No. 15, we learn that the total estimated cost of the Schroon valley system is $1,172,500, which gives, for the total storage of 15,330,000,000 cubic feet, a cost per million cubic feet stored of $76.48. Clearing of all timber below the flow lines is estimated at $4.60 per million cubic feet stored; roads, at $8.05; and logways and fishways at $3.44, making a total for the several items of clearing, roads, logways and fishways, of $16.09 per million cubic feet stored. The estimated cost, not including clearing, roads, etc., is given at $60.39 per million cubic feet stored.

A detailed estimate has also been prepared of the cost of a dam on the Schroon river at Tumblehead Falls (see Plate VIII.), whereby the entire flow of the Schroon area may be controlled by one reservoir. This dam would raise the flow line at the dam fifty-nine feet, and impound the flow of 502 square miles, amounting on a runoff of 13.5 inches to 15,925,000,000 cubic feet. The estimated cost, including clearing, roads, logways, fishways, and land damages is $840,000.

The location for the proposed Tumblehead Falls dam can hardly be surpassed. As shown by the photographic views, Plates M and N, the cliffs of the granitic hill on the east side descend to the water's edge, forming an ideal abutting end for the dam on that side, while the bottom width of the valley is only about 270 feet. It is proposed to construct at this point what is known as a rock-fill dam with its spillway cut in the solid rock of the bluff on the east, from which the material will naturally be excavated for making the rock fill. Plate O. O. gives a general idea of the appearance of this dam and the lake formed by it when carried out.

Such a dam is made watertight by a sheeting of true asphalt concrete on the water side of the rock fill. If properly constructed it will be as permanent as the hills against which it abuts at the ends.

From the preceding estimates it appears that the first cost of the single reservoir is less than the first cost of the system of small reservoirs by $1,172,500 — $840,000 = $332,500. When, however, we also take into account the capitalization of the maintenance, the difference becomes far greater than $332,500. Let us examine this point a little in detail.

The sixteen small reservoirs will require fourteen gatekeepers,* whose salaries, with the occasional assistance they will need, may be taken at $1,000 per year, or $14,000.

In addition the maintenance of sixteen dams may be taken at $1,000 each per year, or $16,000 in all. We have then a total annual expense for gatekeepers and maintenance of dams, etc., of $30,000, which, capitalized at five per cent., is equivalent to a permanent investment of $600,000. Adding $600,000 to $1,172,500, gives a total permanent investment of $1,772,500.

For the single reservoir we may estimate the salary of gatekeeper, with occasional help, at $1,200, and maintenance at an average of $3,800 per year, giving a total estimated annual expense of $5,000, which, capitalized at five per cent., represents a permanent investment of $100,000. Adding $100,000 to $840,000, gives a final total for the single reservoir of $940,000.

The single reservoir is therefore cheaper than the system of small reservoirs by the difference of $1,772,500 and $940,000, which is $632,500.

The area to be flowed by the proposed dam at Tumblehead Falls includes everything below the 840 foot contour as given on Plate VIII. It includes the villages of South Horicon, Bartonville, Starbuckville and parts of Pottersville and Chester. The value of village property at these several places has been taken into account in preparing the estimates, though it must be understood that this part of such an estimate has necessarily more

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* One gatekeeper will answer for Dudley and Overshot ponds, and also for Elk lake and Clear pond.

elements of uncertainty in it than the part relating to the cost of the structures. It is believed, however, that the estimated first cost of $840,000 is large enough to cover the several items which go to make up the total expense.

With total first cost of $840,000, and total storage of 15,925,000,000 cubic feet, the cost, per million cubic feet stored, becomes $52.12; whence the difference in first cost in favor of the single large reservoir, in comparison with the series of small ones, is found to be $76.48—$52.12 = $24.36 per million cubic feet stored.

Other Estimates.

A complete survey of Indian lake is shown by Plate IX. The necessary investigations were also made for a dam at the foot of the lake at about the site of the present lumberman's dam.

Taking into account the cost of clearing, roads, logway and fishway, the estimated cost of Indian lake reservoir for a height of dam of twenty-three feet above the crest of the present dam, and a total storage of 4,468,000,000 cubic feet, is found to be $120,000. This gives a cost per million cubic feet stored of $26.86.

Surveys have also been made at Piseco lake as per Plate X. For this reservoir the storage is found to be 1,725,000,000 cubic feet; and the estimated cost $70,000. Whence there results a cost per million cubic feet stored of $40.

At Hadley only general investigations have been made, from which, as an approximation, the cost of the reservoir, including the changing of the Adirondack Railway location, has been placed at $360,000. As already stated, the cubic contents of this reservoir will be about 4,000,000,000 cubic feet. But we may assume by reason of its location on the main river below several hundred square miles of uncontrolled area (see page 122) that, in effective capacity this reservoir is equivalent to at least 9,000,000,000 cubic feet. On this basis the cost per million cubic feet stored becomes $40. Still it should not be overlooked, that, if based on actual cubic contents, the cost at Hadley becomes $90 per million cubic feet stored; this large cost being due, not only to the change in location of the Adirondack Railway, but to the considerable land damages at the village of Luzerne as well.

By working from the ascertained price per million cubic fe stored, we may now approximate to the cost of that portion of t system on the main North river and on the Sacandaga, for whi the data is incomplete.

The price per million cubic feet stored is, for the Schroon va ley system, $76.48. It is considered that this price is appro mately right for the balance of the system, although the avera of the Schroon valley system (Table No. 15,) is reduced by th large storage of over one-half the total, afforded by the dam a Starbuckville. On the other hand the balance of the system i generally made of considerably larger reservoirs than those o the Schroon system aside from Schroon lake.

Exceptions to the last statement may be found in the case o Boreas ponds and the Cheney pond on the Boreas river, for which two sites estimates have been made. From these estimates it appears that for a total storage, at Boreas and Cheney ponds, of 1,111,000,000 cubic feet, the estimated cost of the reservoirs becomes $118,000, giving a cost per million cubic feet stored of $106.21.

Referring to pages 93 and 94, we learn that with Indian lake, Piseco lake, Boreas ponds and Cheney pond deducted there remains a total drainage area of 458 square miles, for which the data for estimates is not yet available. The storage yield of this area, at 13.5 inches, is 14,364,000,000 cubic feet, which, at a cost of $76.48 per million cubic feet stored, amounts to $1,098,559.

We have then as the approximate cost of the entire system and the storage, the following:

	Storage in cubic feet.	Estimated cost.
Amount as above........	14,364,000,000	$1,098,559
Boreas and Cheney ponds	1,111,000,000	118,000
Indian lake............	4,468,000,000	120,000
Piseco lake............	1,725,000,000	70,000
Schroon valley.........	15,925,000,000	840,000
Hadley.................	4,000,000,000	360,000
Total............	41,593,000,000	$2,606,559

We have then, with 41,593,000,000 cubic feet, at a total cost of $2,606,559, a cost per million cubic feet stored of $62.69.

Assuming that the land damages do not exceed the estimates, it is my present judgment, that the entire system, as outlined in the foregoing, can be completed for $2,600,000. The right to amend is, however, reserved when the complete data shall have been gathered.

COST OF OTHER RESERVOIR SYSTEMS.

In order to show the relative value of the Upper Hudson storage, we will now give the cost per million cubic feet stored at a number of other reservoirs.

(1.) The Bear valley reservoir in California, with a storage capacity of 1,766,358,000 cubic feet, cost $121.67 per million cubic feet stored.

(2.) The Bhatgur reservoir in India, with a storage capacity of 5,510,340,000 cubic feet, cost $73.46 per million cubic feet stored.

(3.) The Long valley reservoir in California, with a storage capacity of 1,433,560,000 cubic feet, cost $50.73 per million cubic feet stored.

(4.) The Erkuk reservoir in India, with a storage capacity of 3,315,000,000 cubic feet, cost $91.83 per million cubic feet stored.

(5.) The Sweetwater reservoir in California, with a storage capacity of 784,080,000 cubic feet, cost $938.70 per million cubic feet stored.

(6.) The Hemmet valley reservoir in California, with a storage capacity of 6,111,280,000 cubic feet, cost $229.16 per million cubic feet stored.

(7.) The Periar reservoir in India, with a storage capacity of 6,969,600,000 cubic feet cost $106.75 per million cubic feet stored.

(8.) The Betwa reservoir in India, with a storage capacity of 1,603,008,000 cubic feet, cost $204.25 per million cubic feet stored.

(9.) The proposed Genesee river reservoir, with a storage capacity of 7,700,000,000 cubic feet, is estimated to cost $311.69 per million cubic feet stored.

We shall see further on that the storage reservoirs at the headwaters of the Mississippi river have cost only $8.56 per million cubic feet stored. This, however, is an exceedingly low price — far less than the average.

We may conclude, therefore, that the Upper Hudson system will be, aside from a few exceptional cases, like the Upper Mississippi, one of the cheapest systems thus far carried out.

MISCELLANEOUS QUESTIONS.

Timber Within the Flow Lines to be Cut.

The State now owns large areas of land in the Adirondack region, to which, for the purpose of establishing a State park, additions are making, under the authority of the Legislature, from year to year. The reservoir system should therefore be made with reference to not only the mere storage of water, but with reference to the final result of a finished park worthy of the great Commonwealth of New York. To this end the vandalism of leaving standing timber below the flow lines must be deemed inadmissible. As the traveler threads his way among the ruins of ancient Rome he sees, on all sides, statues and reliefs still standing in their original positions, but every figure within reach of a man on foot or on horseback has been mutilated by the breaking away of a nose, an ear, a prominent cheek or an extended hand. It was thus that the barbarians, on their incursions into Rome, expressed their contempt for the refined civilization which their prowess had overthrown. Riding through the sacred precincts of the Forum, the Basilica Julia and the deserted Via Sacra, the mighty battle axes mutilated every example of Roman art within reach. The figures too high to be reached by a man on horseback remain intact to this day.

The sins of the State of New York, in leaving standing timber below the flow lines of several reservoirs already constructed in the Adirondacks and adjacent regions, are akin to those of the barbarians, with this difference, that in Rome works of art were mutilated, while in the latter day we have desecrated the face of nature.

To guard against this vandalism in the future the estimates herewith presented have included the cost of cutting and burning all standing timber, undergrowth and brush within the flow lines, clean to the ground.

Roads About the Reservoirs.

In the line of making the reservoirs an attractive feature of the State park, it is deemed desirable to include in the estimates the cost of constructing good roadways about all those situated in the more accessible locations. Those less accessible, such as Elk lake and Boreas pond, which are largely in what is still nearly primeval wilderness may, for the present be possibly left without the roads, though even in such cases it may be properly considered whether the roads should not be constructed as a part of the original work, thus placing all parts of the territory on an equality. The estimates herewith presented include the making of roads around all the reservoirs.

Illustrative examples of such roads may be found in England about the new Vyrnwy reservoir of the Liverpool water supply in the Welsh mountains, and in the new Manchester water supply at Lake Thurlmere. In both these cases the reservoirs have been made the most attractive features of the region by such constructions. As I saw these fine reservoirs last year, it was forcibly impressed upon me that the small amount of money required to construct the roads could hardly have been better expended.

Effect of the Reservoirs on Health.

The Adirondack country, like all sandy regions, is now extremely healthful, and the State ought not to do anything to deteriorate it in this particular. Generally speaking, there are but few marshes, and so far as can be learned, none of these have ever been considered the cause of serious sickness.

The lakes have mostly sandy, gravel or boulder beaches, on which the annual fluctuation has absolutely no ill effect. With the proposed system the few existing marshes will be covered with water during July and August, when malarial influences are exerted, if at all. As the matter now stands, before July and August, as well as after, the low temperature prevents serious malarial influence from the existing marshes, and will equally prevent such influence from exposed areas in September and October after the completion of the reservoir system. The cutting of the timber below the flow lines clears the way for the waters to quickly form a new beach line with sand, gravel and boulder beach the same as now exists, and equally free from all deleterious influences on health.

We may eonclude then, that the raising of the water levels during July and August will be on the whole an advantage to the health of the region rather than an injury.

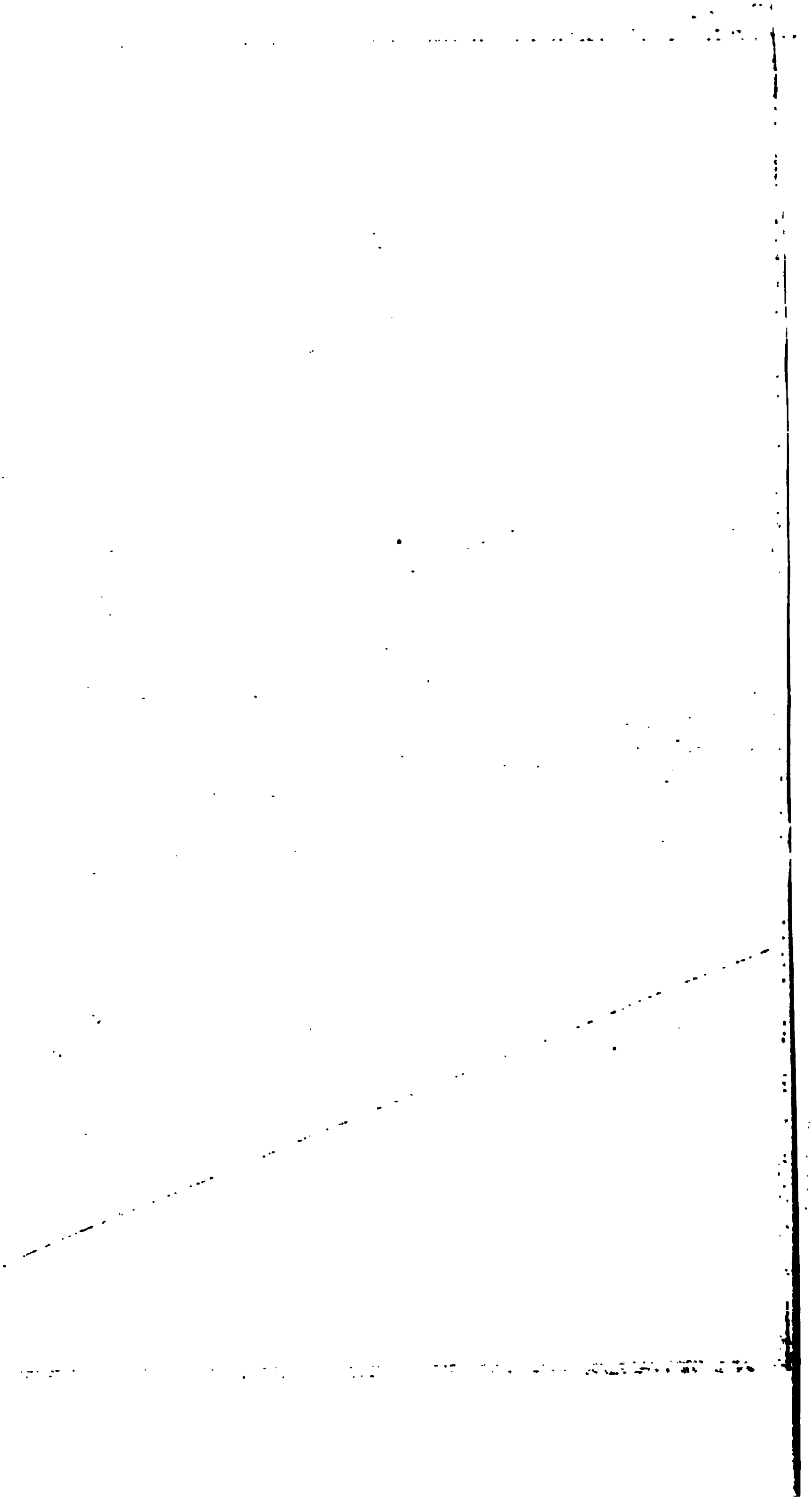
Effect on Fish.

Sections 260-263 of Article XI. of the revised Game Laws of 1895, provide that no dam shall be constructed by the State or any person upon any stream more than six miles in length inhabited by fish protected by the Game Laws, except, that, under authority and direction of the Fish, Game and Forest Commissioners, a fishway be erected at every such dam. Penalties are provided in case of failure or refusal to comply with the provisions of the law.

The estimates herewith submitted have, therefore, included the erection of substantial fishways at all the dams.

At present not one of the dams in the Upper Hudson area is provided with a fishway; hence, when compared with existing conditions, the reservoir system must be considered as in this particular an improvement.

Probably, however, the more interesting question to fishermen, at any rate, will be as to the effect of the reservoirs upon the increase of fish. On this point it may be observed that, where



natural conditions exist, an increase or decrease in the number of fish inhabiting a given body of water will depend more upon the sufficiency of the food supply than upon all other causes combined. The rational line of inquiry, therefore, is as to whether the construction of the reservoirs will, on the whole, tend to increase the favorite foods of the fish inhabiting the Adirondack waters; if it does, then, other things remaining equal, we may expect an increase in the number of fish.

An enumeration of the several species of fish found in these waters and their food preferences, would be out of place in this report, and we may merely point out where the detailed information may be obtained.

As to the species a fairly complete list may be found in a report by Mr. Fred Mather, in the annual report of the State Land Survey for 1891.*

The question of the food preferences of the different species of fish is thoroughly discussed by Professor S. G. Forbes of the Illinois State University, in the various bulletins of the State Laboratory of Natural History of that State,† and reference is accordingly made thereto for the most authentic information on this phase of our subject to be obtained anywhere. Mr. Mather has also pointed out in his report that fish food is now abundant in the Adirondack waters; and its maintenance or possible increase becomes largely the key to an increase in the fisheries.

Without going into detail it may be stated that the construction of the reservoirs will not be in any degree prejudicial to the growth of the various kinds of fish food now found in these waters. The considerable increase in water area and volume for a part of the year may even be considered very favorable.

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* Memoranda Relating to Adirondack Fishes, with Description of New Species, from Researches made in 1882. By Fred Mather.

† Published at intervals from 1877 to 1888 in the Bulletins of the State Laboratory, the following: (1) The Food of Illinois Fishes, Vol. I., No. 2, pp. 71-89. (2) The Food of Fishes, No. 3, pp. 18-65; also reprinted in report of Illinois Fish Commission for 1888, pp. 90-127. (3) On the Food of Young Fishes, No. 3, pp. 66-79. (4) The Food of the Smaller Fresh Water Fishes, No. 6, pp. 65-94. (5) The First Food of the Common White Fish, No. 6, pp. 95-109. (6) Studies of the Food of the Fresh Water Fishes, Vol. II., Art. VII., pp. 433-473. (7) On the Food Relations of Fresh Water Fishes: A Summary and Discussion, Art. VIII., pp. 475-538.

The question has been raised by a number of fishermen as to whether the flooding of the marshes will not tend to kill the fish, and cases have been cited where the flooding of one of the Adirondack lakes has been followed by the death of large numbers of fish.

In answer it may be stated that the mere fact of large numbers of fish perishing subsequent to the flowing of the margins of one of these lakes, is no proof of any connection between the two. Fish frequently suffer from epidemics the same as human beings. This fact has been impressed upon the writer very markedly in the course of several years' close observation of Hemlock lake, the source of the water supply of the city of Rochester.

This lake, with clean gravel beaches and an area of 1,828 acres at low water, is never raised above the ancient beach line, yet on several occasions the perch and bass have perished in such quantities that as many as six to ten bushels of dead fish have been gathered up around the shores in a week.

It is possible, however, if a large area of standing timber and rank undergrowth were to be flooded, there might be such an access of organic matter to the water as to be prejudical to the fish. Our proposed clearing and burning of everything in the way of timber and brush below the flow lines is believed to be a satisfactory corrective of this evil. The other side of the question is the great natural purity of these waters, which, filtered as they are largely through the extensive sand areas of the region, reach the lake in a condition of ideal purity. This consideration with the others advanced renders it extremely improbable that any harmful influence will result.

Similar Reservoir Systems Elsewhere.

The idea of constructing such a system of regulating reservoirs as is here proposed is not a new one. Similar systems have been carried out in Europe, while here the Federal government has constructed an extensive series on a number of streams tributary to the Upper Mississippi, for the benefit of navigation on that stream.

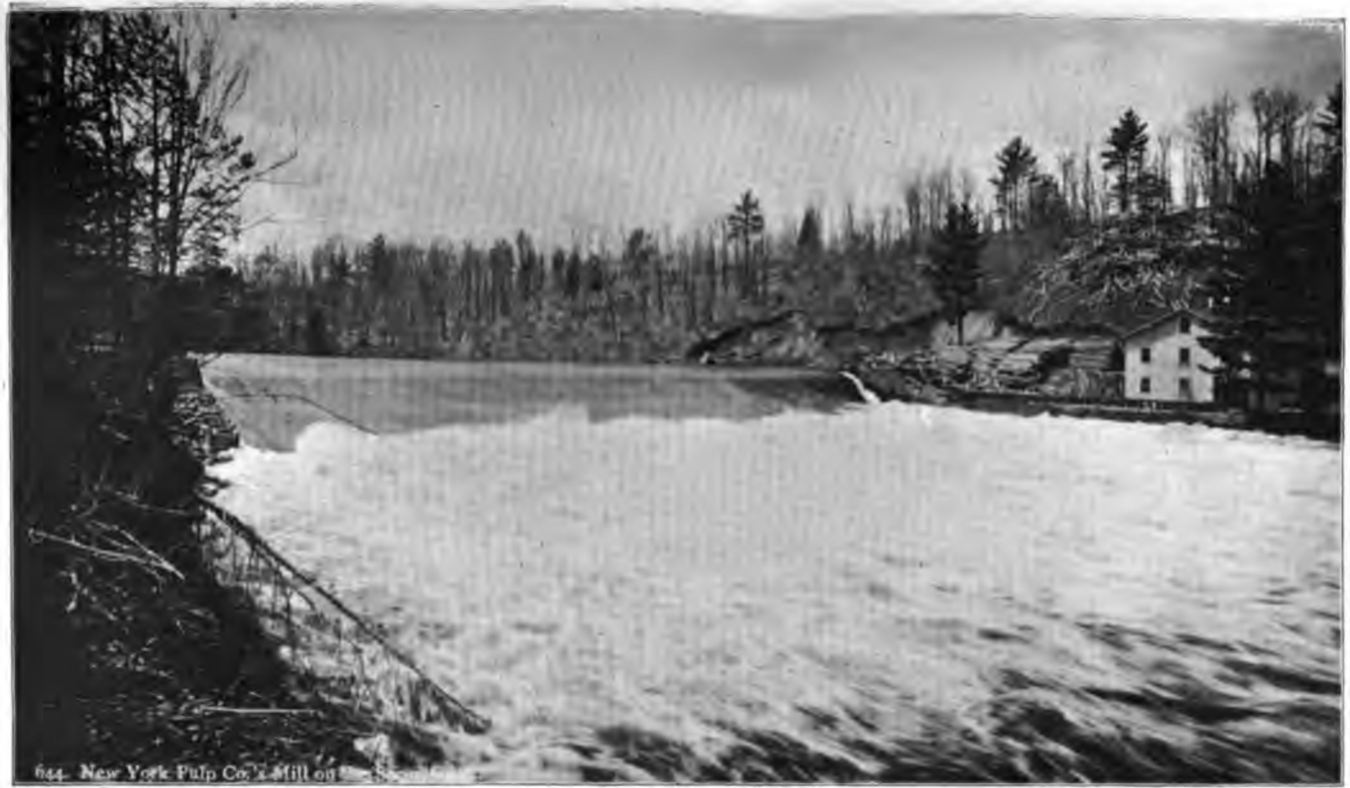

Plate T.—High Water on the Sacondaga River.

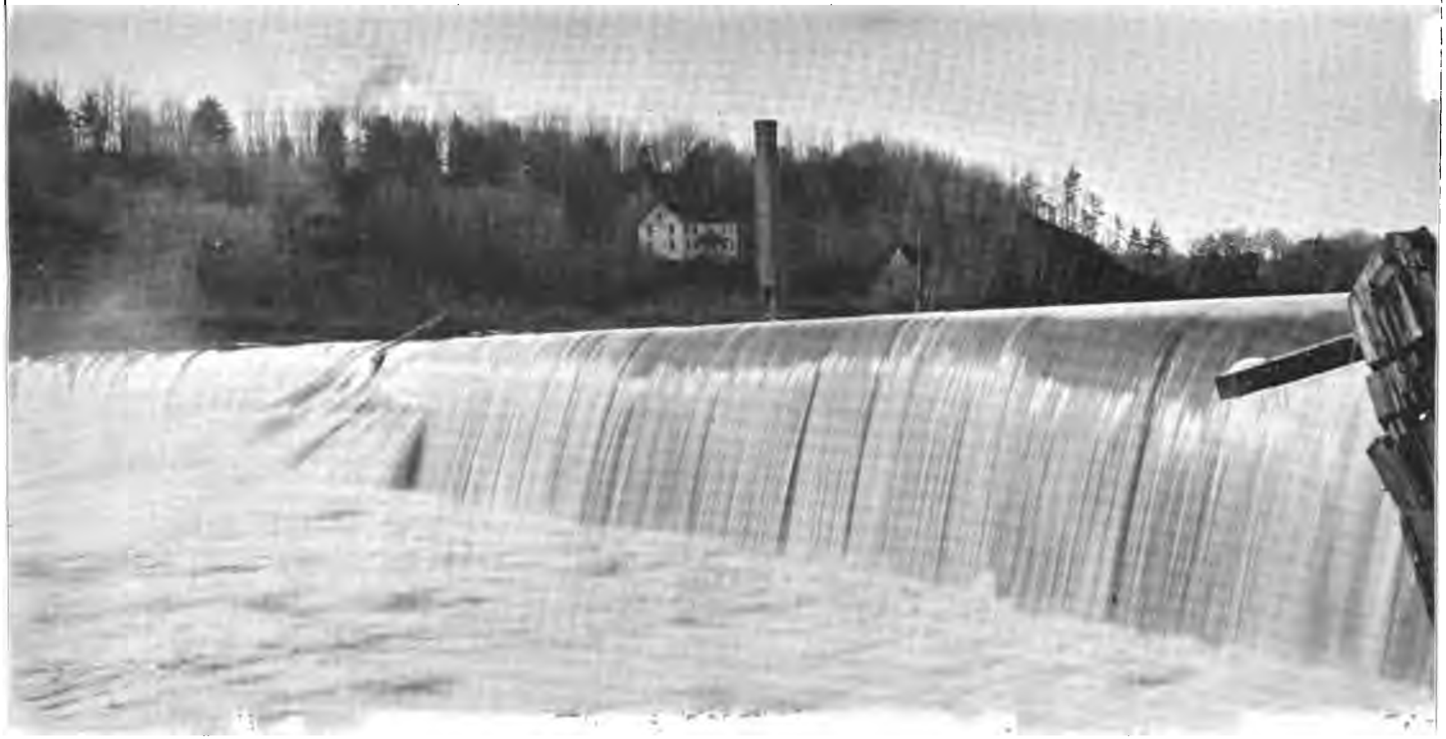

PLATE U.—ANOTHER VIEW OF HIGH WATER ON THE HUDSON.

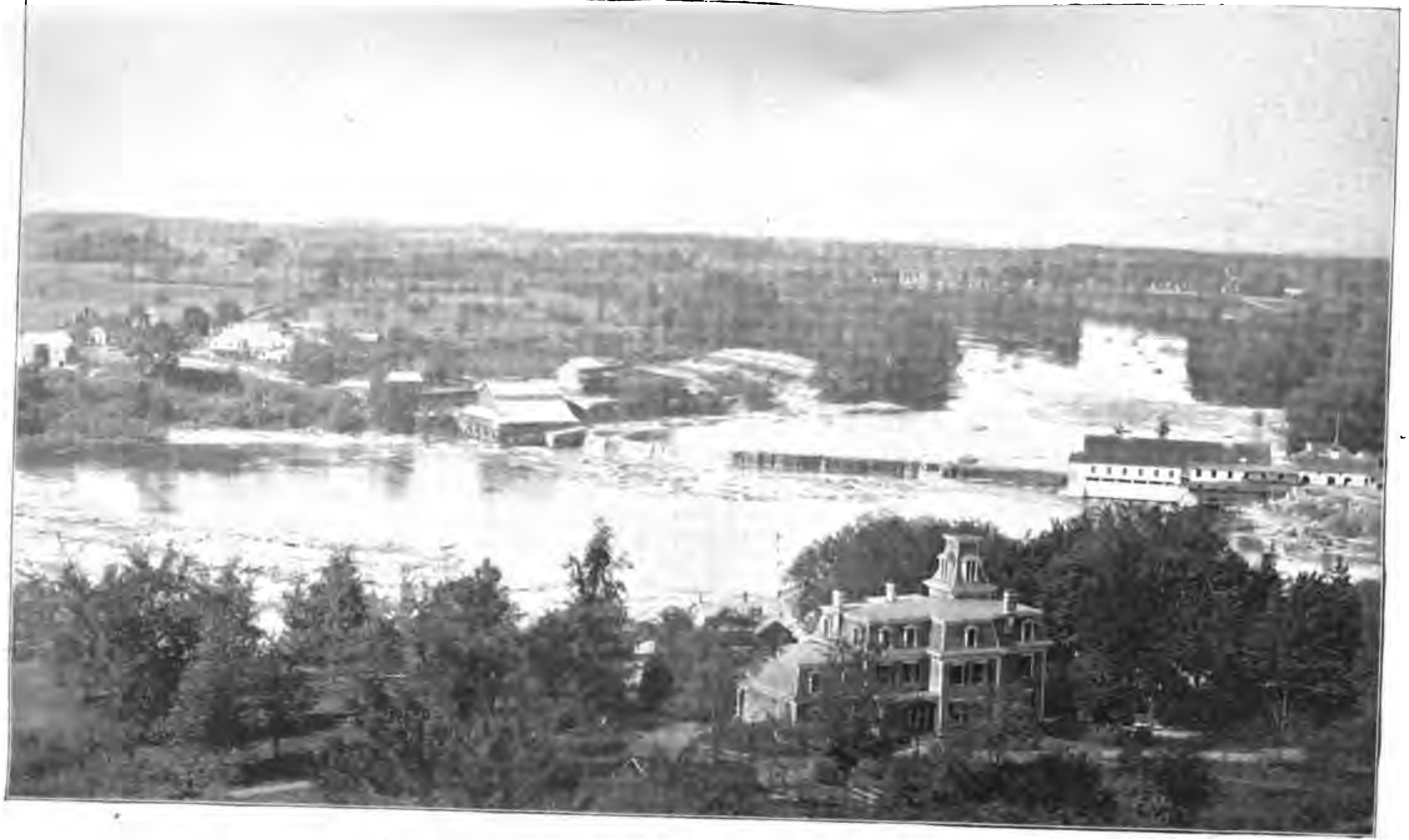

Plate V.—A General View of the Sandy Hill Power Co.'s Plant.

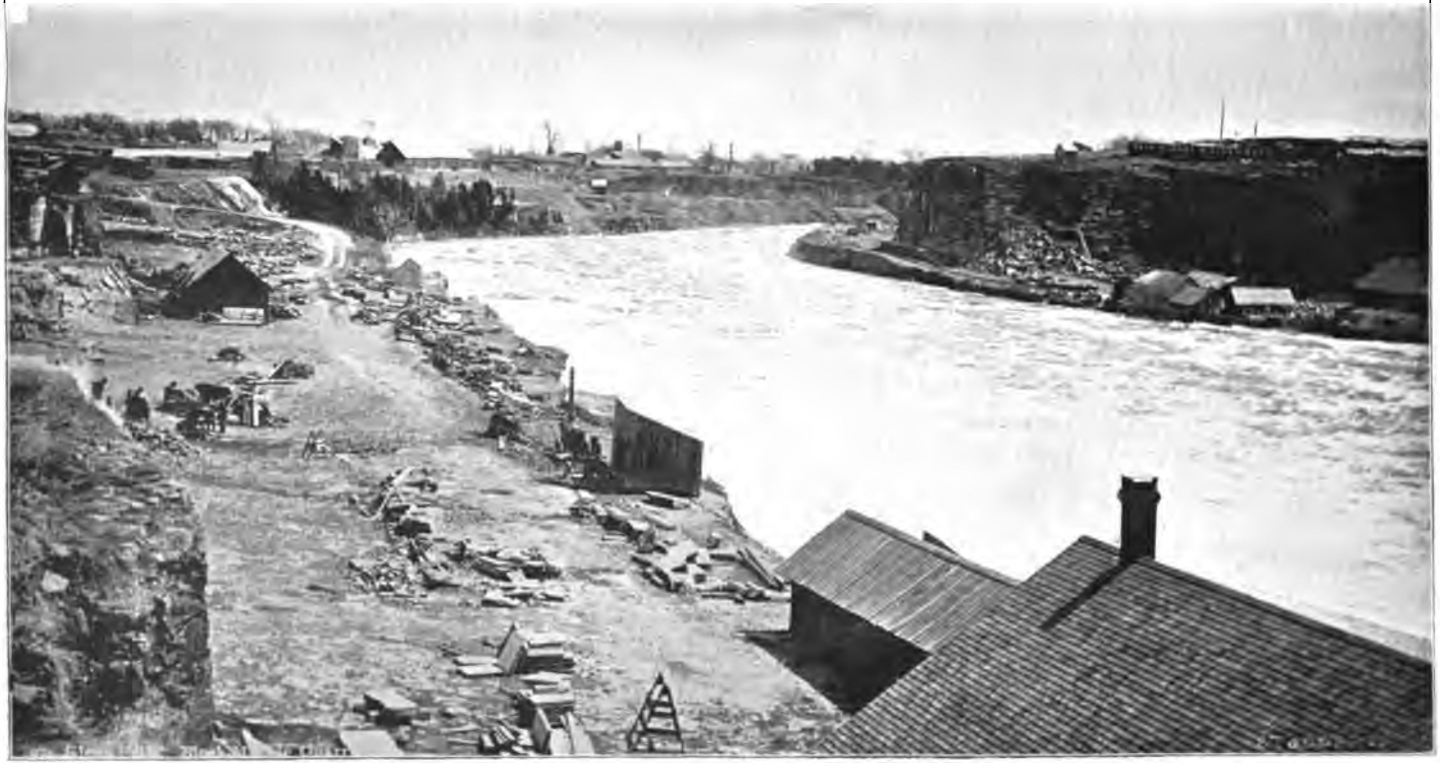

PLATE W.—HUDSON RIVER JUST BELOW GLENS FALLS.

The storage provided by these reservoirs has not only greatly improved navigation but they have also resulted in incidental benefit to the water powers of the several tributary streams as well as to the water power of the Mississippi itself at the Falls of St. Anthony.

It was my intention to visit these reservoirs in order that all the detail of their inception, construction and management might be at hand as a guide for the future in this State, but the time at my disposal has not permitted of such work this year. For the present, then, we may refer to the various reports of the government engineers to be found in the annual reports of the Chief of Engineers.

The Upper Mississippi reservoir project was inaugurated in 1880 by an act of Congress authorizing the construction of the first reservoir, of the system at Lake Winnibigoshish. The entire system as originally designed includes forty-one reservoirs in the States of Wisconsin and Minnesota, estimated to cost, exclusive of land damages, the sum of $1,809,083. The whole system including the land damages may be expected to cost in the vicinity of $2,500,000. At present five reservoirs have been completed at a total cost, including land, as well as maintenance and operation to June 30, 1894, of $771,093.67. The completed reservoirs are: Lake Winnibigoshish, completed in 1883-84; capacity 45,800,000,000 cubic feet. Leech lake, completed in 1894; capacity 30,000,000,000 cubic feet. Pokegama falls, completed in 1894; capacity 4,700,000,000 cubic feet. Pine river, completed in 1886; capacity 7,500,000,000 cubic feet. Sandy lake, completed in 1892; capacity 2,086,000,000 cubic feet.

The total capacity of the five is 90,086,000,000 cubic feet. Whence we derive from the total cost of $771,093.67, a cost per million cubic feet storage of $8.56. The tributary drainage areas are, Lake Winnibigoshish, 1,442 square miles; Leech lake, 1,163 square miles; Pokegama lake, 660 square miles; Pine river, 562 square miles, and Sandy lake, 421 square miles. The entire drainage area tributary to the completed reservoirs is therefore 4,248 square miles.

The total drainage area of the Mississippi above St. Paul is 36,081 square miles.

Flow Line of Upper Mississippi Reservoirs.

In the original design of these reservoirs it was assumed in the absence of definite data as to runoff of the tributary streams, that about one-third of the mean annual rainfall of twenty-five inches could be collected, and the flow lines were accordingly located in accordance with that view. Experience has, however, shown that the early reservoirs are unnecessarily large. Observations kept at the reservoirs themselves for nine years show a range in the annual rainfall from 19.85 inches at Pine river dam in 1891, to 28.35 inches in 1885, at Lake Winnibigoshish. For the years observed, 1885 to 1893, inclusive, the mean rainfalls are: At Leech lake, 24.05 inches; Lake Winnibigoshish, 24.95 inches; at Pokegama dam, 25.21 inches; and at Pine river, 22.98 inches.

The gagings of the actual outflows from the reservoirs for the eight years show a runoff equal to from about 17 to 18.5 per cent. of the rainfall. On this basis an annual rainfall of twenty-five inches will yield in the streams 4.5 inches of runoff. But in the years of minimum rainfall of twenty inches and seventeen per cent. collected, the runoff becomes as low as 3.40 inches.

It is apparent from the foregoing figures that a reservoir on the Upper Mississippi designed on the supposition that at least seven to eight inches of runoff may be impounded in the year of minimum rainfall is far larger than necessary for the observed minimum runoff of only 3.40 inches.

It is now perfectly clear that if the entire runoff were held back in such a reservoir it would require from twenty-six to twenty-seven months to fill.

This error in location of height of flow line of the Upper Mississippi reservoirs is referred to here merely to enforce the proposition that such data as that afforded by the Mechanicville gagings has great economic value when considering questions of river conservancy. In justice to the Government engineers it should be stated that the early reports show they realized how thoroughly, in the absence of such data, they were groping in the dark.

It is also clear that although these reservoirs show a total capacity of 90,086,000,000 cubic feet, as a matter of fact no such yearly storage will ever be realized while the rainfall remains substantially as indicated by the nine years' observations at hand. Aside from the rainfall statistics already given, a mere statement of actual annual outflows from the reservoirs will further serve to make this plain.

The outflow from Leech lake and Lake Winnibigoshish passes through the Pokegama reservoir, which is therefore used as the regulator of the whole of this portion of the system, in the same way as proposed for the Hadley reservoir in our system. The actual total capacity of these three reservoirs as built is 80,500,000,000 cubic feet. During the nine years from 1885 to 1893, inclusive, the total quantity collected was 284,238,000,000 cubic feet. Of this 1,587,700,000 cubic feet remained in store at the end of the nine year period. We have then a total outflow of 282,648,000,000 cubic feet, or a mean outflow per year of 31,405,000,000 cubic feet. The largest outflow of the nine year period was 44,776,000,000 cubic feet in 1888, in which year the rainfall was about twenty-seven inches; while the smallest outflow was 22,320,000,000 cubic feet in 1891 when the rainfall was about twenty-five inches. It is not clear however, from the record, whether all the water in store was drawn out this year or not.

We may also draw the useful conclusion that the absence of definite data as to the runoff has cost, in the case of the Upper Mississippi reservoirs, a number of hundred thousand dollars.

Benefits to Navigation Derived from the Upper Mississippi Reservoirs.

The beneficial effect of these reservoirs extends from Grand Rapids to Lake Pepin, a distance of 421 miles. This reach of river divides naturally into two sections, namely, 373 miles above the falls of St. Anthony and forty-eight miles below those falls.

The effect of the reservoirs thus far has been to increase the low water depth from one to one and one-half feet below St. Anthony's falls, as shown by the St. Paul gage, thirteen miles below. Above the falls, where the channel is generally narrower, the increase is probably somewhat greater, but definite determinations are not yet at hand. This section of the river is rapid in several places at low water, and the greatest benefit to commerce, here, occurs to the logging interests, which are stated to amount to the equivalent of 1,000,000 tons of freight a year.

The portion navigable by steamers in a large way, is that below the St. Anthony falls.

Gagings have also been made of the flow of the Mississippi river at St. Paul, from which it appears that when the water stands at 2.0 feet on the river gage, the flow is about 4,400 cubic feet per second; at 3.0 feet on the gage, the flow is 6,300 cubic feet per second; and at 4.0 feet, the flow is 8,000 cubic feet per second. Within the limits of 2.0 to 4.0 feet, therefore, an increase in flow of 3,600 cubic feet per second adds 2.0 feet to the depth. The entire system when constructed will furnish at least 8,000 cubic feet per second for a low water period of 100 days.*

Water Power Reservoirs in New England.

In the New England States as well as most of the Southern and several Western States, there are a series of statutory enactments which are designed to encourage the erection of mills. Under their provisions parties desiring to flow the lands of others for the purpose of creating water power to propel mills, may do so under condemnation proceedings analagous to those for acquiring lands and property for canals, railways and other public purposes. This peculiar extension of the principle of eminent domain has grown out of the original conditions of interdependence of the early colonists to whom mills for grinding grain were among the necessities of life. The first Mill Acts originated in

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* For information as to the upper Mississippi reservoirs the three volumes of indexes to the Annual Reports of the Chief of Engineers furnish full reference.

Massachusetts and Virginia, from whence they have been adopted into the statutes of most of the other States.

Generally speaking, the Mill Acts have been limited to grain mills, but in New England, where the Legislatures have always been mindful of the manfacturing interests of the people, the principle has been extended to apply to the development of storage reservoirs, by power and manufacturing companies, at points on the head waters of streams remote from the site of the establishments benefited.

In New York State no Mill Act has ever been enacted, although the Legislature has, in a number of cases, in effect recognized the principle which they embody. As for instance, in Chapter 235, Laws of 1854, an act for the improvement of the Saranac river and lakes; Chapter 505, Laws of 1865, an act for the improvement of the navigation of the Oswegatchie river, and of the hydraulic power thereon, and to check freshets therein; and in Chapter 289, Laws of 1868, an act to provide for the improvement of the hydraulic power of the Great Chazy river and to check freshets therein.

By the terms of these acts Commissioners are appointed who may erect dams; and, if possible, to agree on terms with the owners, purchase the necessary lands, taking a conveyance thereof to themselves, their heirs and assigns forever. If they can not agree on the terms of purchase, then title may be acquired under the general condemnation laws of the State.

While it is stated that these acts recognize the principle of the Mill Acts, still, if called upon to defend them, their originators would probably hold the improvement of navigation, the checking of freshets, as the real matter of public utility.

Probably other similar laws have been enacted at various times, but these are the only ones to which I have reference at this time.

Although we have no Mill Act in New York State, we nevertheless reap the benefit on the Hudson river of the Mill Act in the neighboring State of Massachusetts. On the headwaters of the Hoosac there are two such reservoirs of considerable extent, which operate to the benefit of the water powers on the Hudson at Mechanicville and Troy, as well as the navigation of the Lower Hudson. Thanks to State lines, we receive this benefit without cost to anybody in the State of New York.

The greatest development of these water power reservoirs is probably in Rhode Island and Connecticut, although they are common in Maine, New Hampshire and Massachusetts.

The absence of such legislation in this State is to be traced largely to the growth of the idea here that the navigation interests are paramount to those of manufacturing; whence it has resulted that the important streams of this State have been mostly reserved for the benefit of the internal navigation system, although the showing, on pages 161 and 171, as to the value of the water of the Hudson river for water power, in comparison with its value for the use of navigation, may well lead us to consider whether, after all, the manufacturing interests of this State are not quite as worthy of consideration as those of the neighboring New England States. We ought not to forget, that, aside from carrying grain for producers outside of this State, the chief business of the canals must come from fostering manufacturing interests within the State itself.

State Ownership of the Hudson River.

Titles to lands bordering on and lying under the beds of large rivers like the Hudson, have been somewhat complicated in this State by the peculiar circumstances of its early settlement and history. Thus, all original titles in the Lower and Middle Hudson valley, as well as in the most of the Mohawk valley, are derived from the laws of Holland as they existed early in the seventeenth century. Under the Dutch law the riparian proprietors owned neither the beds nor banks of streams, but both remained the property of the State. When the Colony of New Netherlands passed into the hands of the English government, the colonists were assured the peaceful enjoyment of all the rights they then possessed. The beds of large streams, never having been

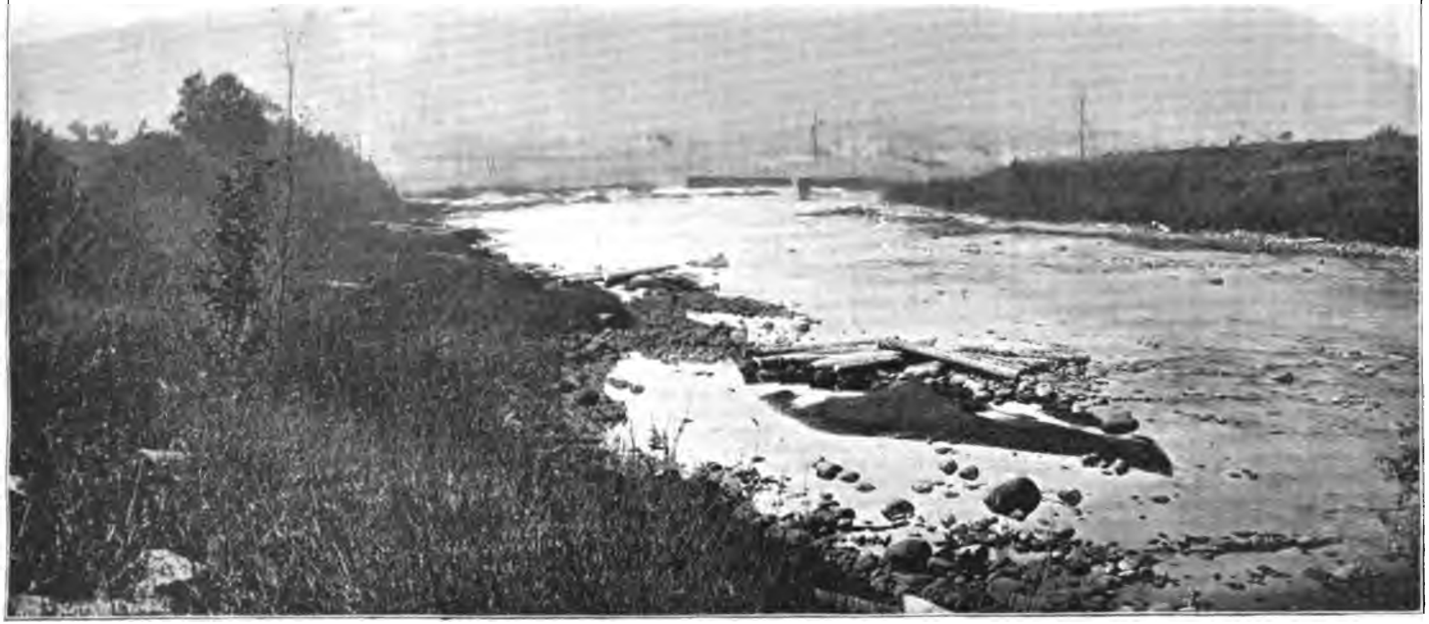

Plate X.—View of Rapids at North Creek, Showing Possibility of Power, Development at That Place.

PLATE V.—GENERAL VIEW OF THE DAM AT MECHANICSVILLE.

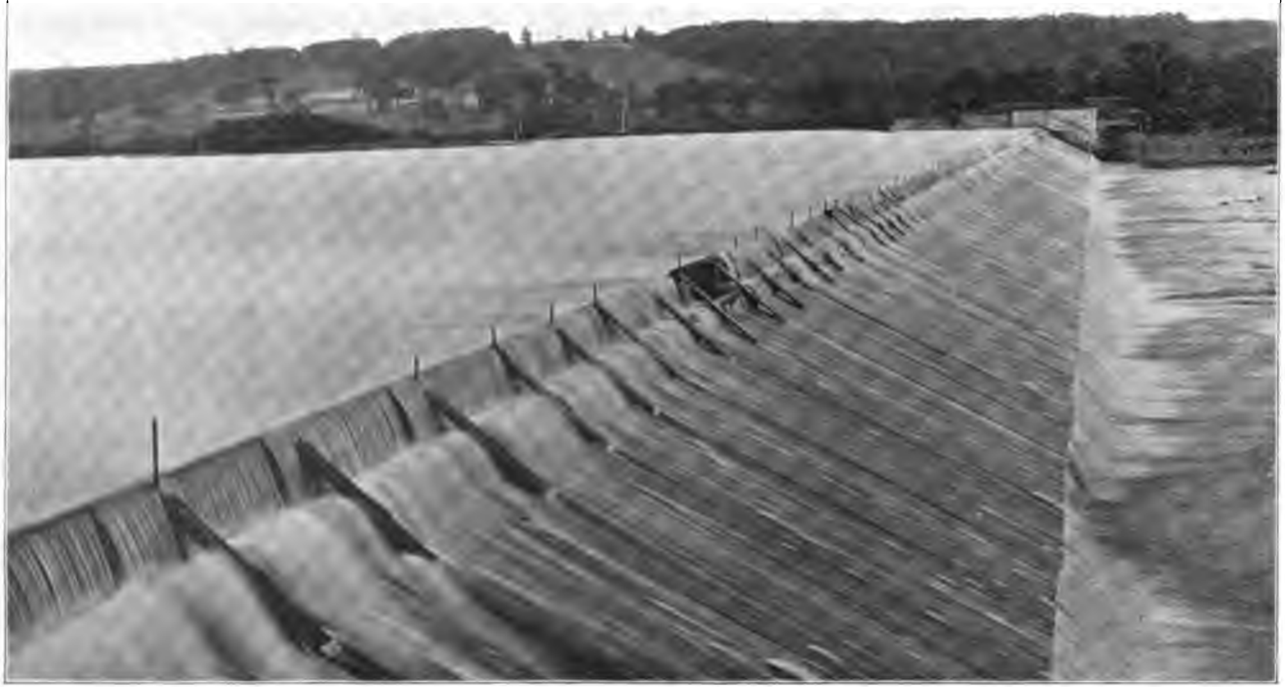

PLATE Z.—THE DAM AT MECHANICSVILLE WITH FLASH BOARDS IN PLACE.

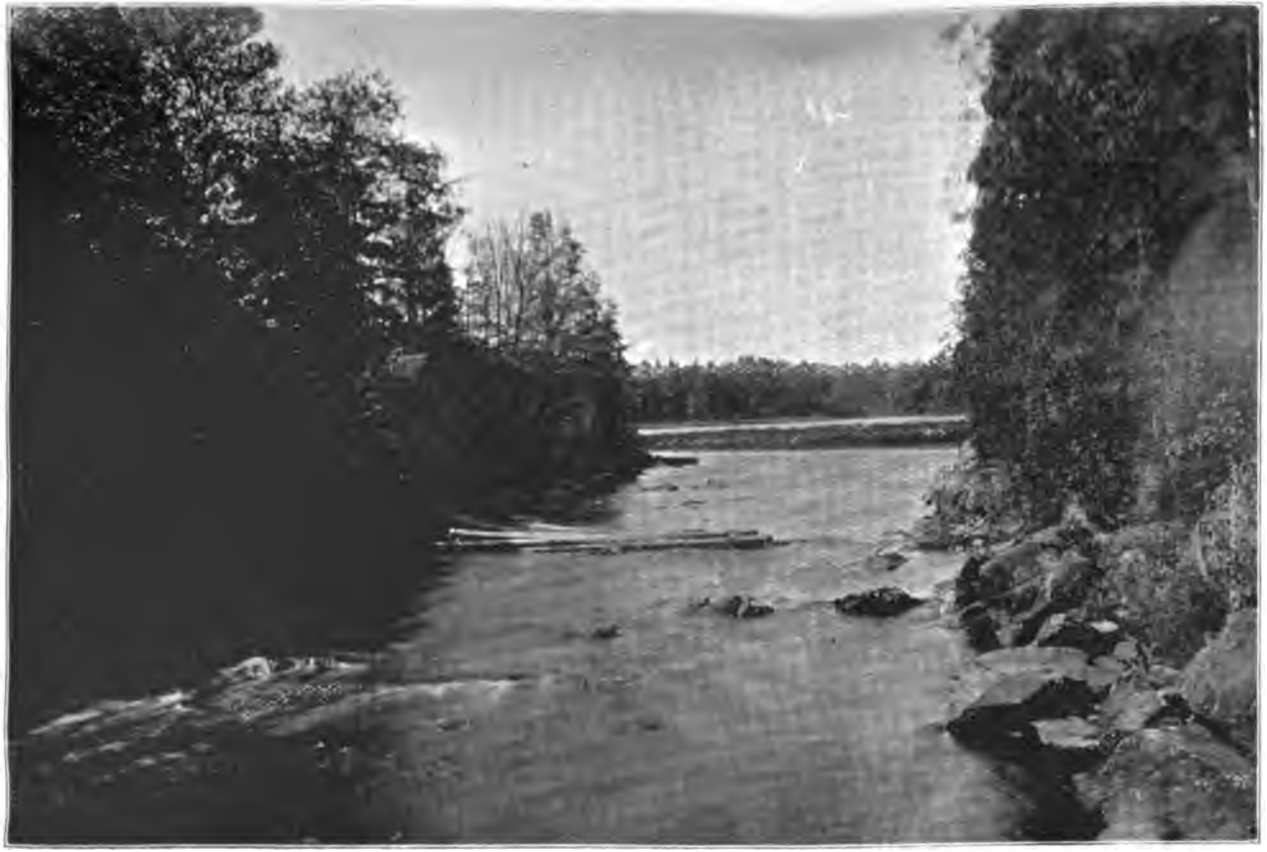

PLATE A A.—SITE FOR DAM ON THE OUTLET OF LAKE PLEASANT.

conveyed became, then, vested in the English government as ungranted lands, to which, as a consequence of the Revolution, the State of New York succeeded in due course.

Throughout the Colonial, as well as the early State period, this right seems never to have been questioned; it was only after the beginning of the era of internal improvement that questions arising under this head became leading ones in the jurisprudence of this State.

The English common law, which became in force in the Colony of New York after the English occupancy, differs from the civil law of Holland in affirming the right of the riparian proprietors, not only to the banks of non-navigable large streams, but also to the beds thereof and, hence, to a right to the flow of the water paramount to that of the State, which could only acquire rights therein by the exercise of eminent domain and the granting of just compensation.

The principle of State ownership of the Hudson and Mohawk rivers was strongly asserted over one hundred years ago, in 1792, when, on March 30, of that year, an act passed the Legislature incorporating the Western Inland Lock Navigation Company, having for its object the improvement of navigation of the Mohawk river from the navigable portion of the Hudson to Rome, and thence to Lake Ontario and Seneca lake; and the Northern Inland Lock Navigation Company, having for its object to open a like communication from the navigable part of the Hudson river to Lake Champlain. In an amendment to this act, passed December 22, 1792, it is provided that all the land under the Mohawk and Hudson rivers, which may be occupied by those corporations is vested in them during the continuance of the franchise, "as a free gift from the people of this State," saving and reserving to the people the right to all the lands under the water not so occupied as aforesaid, to be appropriated as the Legislature might from time to time direct.

Again, later on, in 1823, the State acquired by purchase, all the rights in the Hudson and Mohawk rivers, which these two companies were possessed of; which purchase has been taken as reconfirming the State's absolute title to the beds and waters of these two streams.

We will now briefly abstract some of the more important cases bearing upon the ownership of the Hudson river, which have been passed upon by the courts of last resort in this State.

The first important case is that of the Canal Appraisers v. The People, on the relation of George Tibbetts, determined in the Court of Errors in 1836. In this case it was held, that, if, in the improvement of a navigable river, the waters of a tributary stream are so much raised as to destroy a valuable mill site situate thereon, and if the tributary stream on which said mill site is situate, be generally navigable, although not so at the particular locality of the mill site, the owner is not entitled to damages within the provisions of the canal laws, directing compensation to be made for private property taken for public use.

In this case Tibbetts claimed damage for the destruction of a water power situate in the middle sprout of the Mohawk river, by the erection of the Troy dam. The case was first tried in the Supreme Court in 1826, when the relator obtained a rule that the Canal Appraisers should show cause why a mandamus should not issue commanding them to assess the damage. The Canal Appraisers had refused to allow damages, assigning as a reason that Tibbetts had no legal claim to the land under the water of the middle sprout because it belonged to the people of the State. After various proceedings, which need not be specially referred to here, the Court of Errors held as in the foregoing, thereby confirming the position of the Canal Appraisers.*

In the case of The People v. Tibbetts, decided by the Court of Appeals in 1859, it was held that the State in its sovereign character owns the beds of navigable streams to high water mark, and that the right of a riparian owner is subservient to the power in the State to abridge or destroy it at pleasure, although the riparian owner may undoubtedly use the water passing his land so long as he does not impede the navigation, in the absence of any counter claim by the State as absolute proprietor. The court said: "It is beyond dispute that the State is the absolute owner of the navigable rivers within its borders, and that as such owner it can dispose of them to the exclusion of the riparian owners." *

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* The Canal Appraisers v. The People, 17 Wendell, 576.

In the case of The People v. The Canal Appraisers, decided in 1865, the following points are passed upon affirmatively:

(1.) The Mohawk river is a navigable stream and the title to the bed of the river is in the people of the State.

(2.) Riparian owners along the stream are not entitled to damages for any diversion or use of the waters of the Mohawk river by the State.

(3.) It seems the common law rules determining what streams are navigable are not applicable in this country.

This was a proceeding by mandamus, decided by the Supreme Court and carried to the Court of Appeals, to compel the Canal Appraisers to assess and appraise the damages which one A. Loomis had sustained by the diversion of the Mohawk river at Little Falls, for the purposes of the Erie canal. After a learned discussion of the several questions involved, the court held as in the foregoing (1), (2), (3); the judgment of the Supreme Court was affirmed and the mandamus denied.†

Without discussing the question more elaborately, we may conclude it is well settled doctrine, that the banks to high water mark, and the beds and waters of the Mohawk and Hudson rivers are the property of the State, and may be disposed of as the Legislature may see fit, and absolutely without reference to the rights of abutting proprietors. Acting on this view the Erie and Champlain canals have taken water supplies from these two rivers and payments of damages have never been made to anybody. As regards the Hudson river the principle, so far as can be learned, has never been questioned since the Legislature first saliently affirmed it by the enactment of 1792. For 103 years, the State's right to absolute control of the Hudson river has been a fixed fact, alike recognized by the courts, canal officials, and the owners of abutting lands.

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* The People v. Tibbetts, 19 N. Y. 523.

† The People v. The Canal Appraisers, 33 N. Y. 461.

Although not specially germane to the subject, it may be remarked in passing that this condition of absolute State ownership only applies to the Hudson and Mohawk rivers. The titles to lands bordering on the balance of the large rivers of the State have mostly originated since the English occupancy and the common law rule governs. Lack of appreciation of this distinction, on the part of the Canal Appraisers, has led to a number of extensive litigations. One of these is Kempshall v. The Commissioners of the Canal Fund, decided in 1842, wherein it is expressly held that the banks and bed of the Genesee river belong to the riparian owners, and that even though the stream had been legislatively declared a public highway, still such declaration only gave rights of navigation on the stream itself, and did not in any degree confer upon the State the right to divert its waters into another channel, as the Erie canal, without first obtaining such right by an exercise of eminent domain and the granting of just compensation under due process of law.*

If, then, the State's title to the water of the Hudson river is complete, there is still responsibility attached to such ownership. The conditions leading to this ownership were peculiar and exceptional and at variance with the rules governing not only in the balance of the State of New York but in most of the other States as well. When the Legislature first affirmed this principle 103 years ago, manufacturing, as any considerable element of our State and National wealth, was an unknown quantity. Its phenomenal development since then has created conditions and needs so entirely different, that if we attempt to decide the questions of to-day by the old standard we will simply paralyze the industries of the locality.

As regards the paramount right of the State to the waters of these streams, it may be assumed that the only direction in which the State is likely to exercise this right is in the interests of navigation, and, inasmuch as its exercise for this purpose on the tidal section can only be of benefit to the other interests on the stream, there is every reason why such an exercise of the right should be made.

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* Kempshall v. Commissioners of the Canal Fund, 26 Wendell, 404.

PLATE BB.—UNDEVELOPED WATER POWER ON THE INDIAN RIVER.

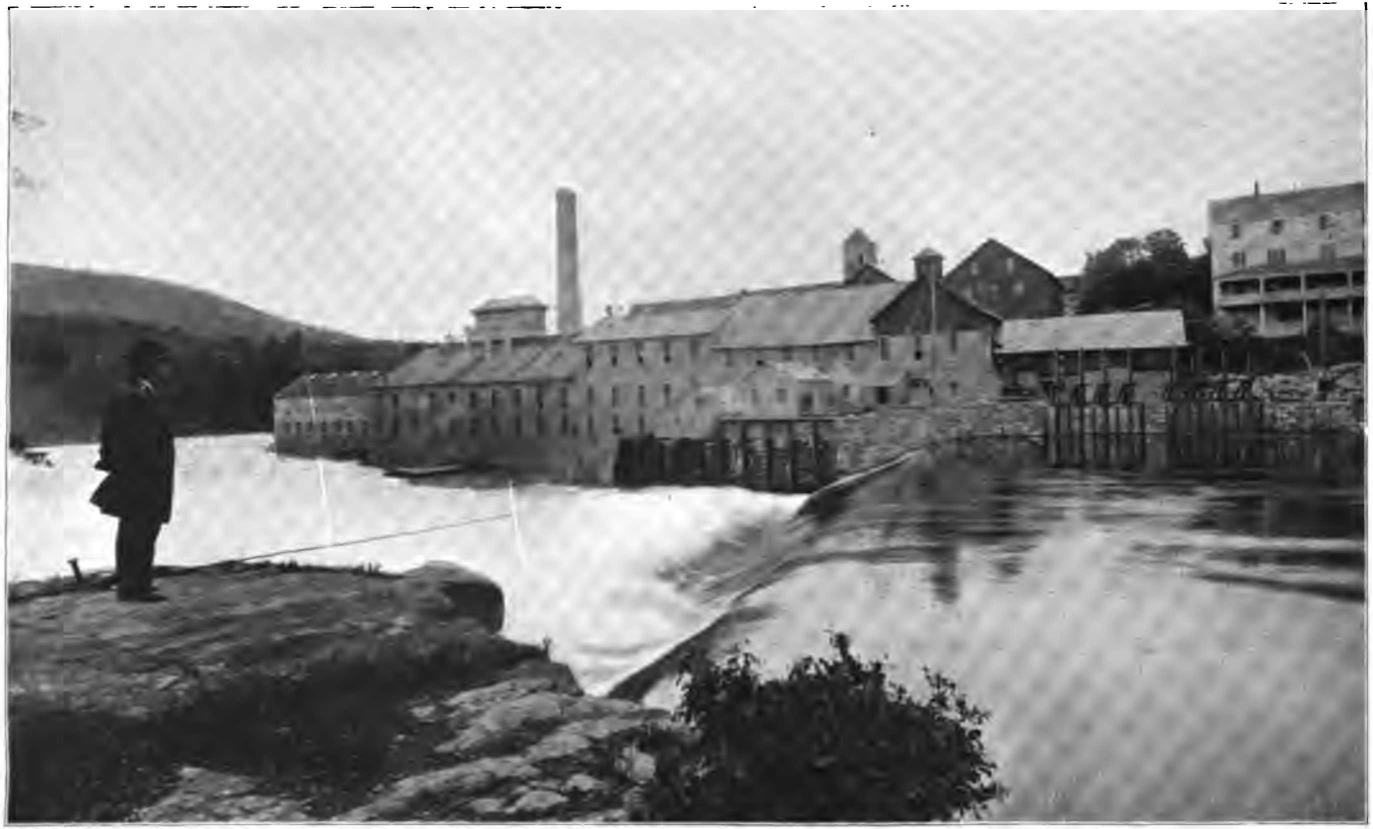


Plate CC.—The Present Dam at Hadley, not to be Disturbed by the Proposed Storage Dam at that Place.

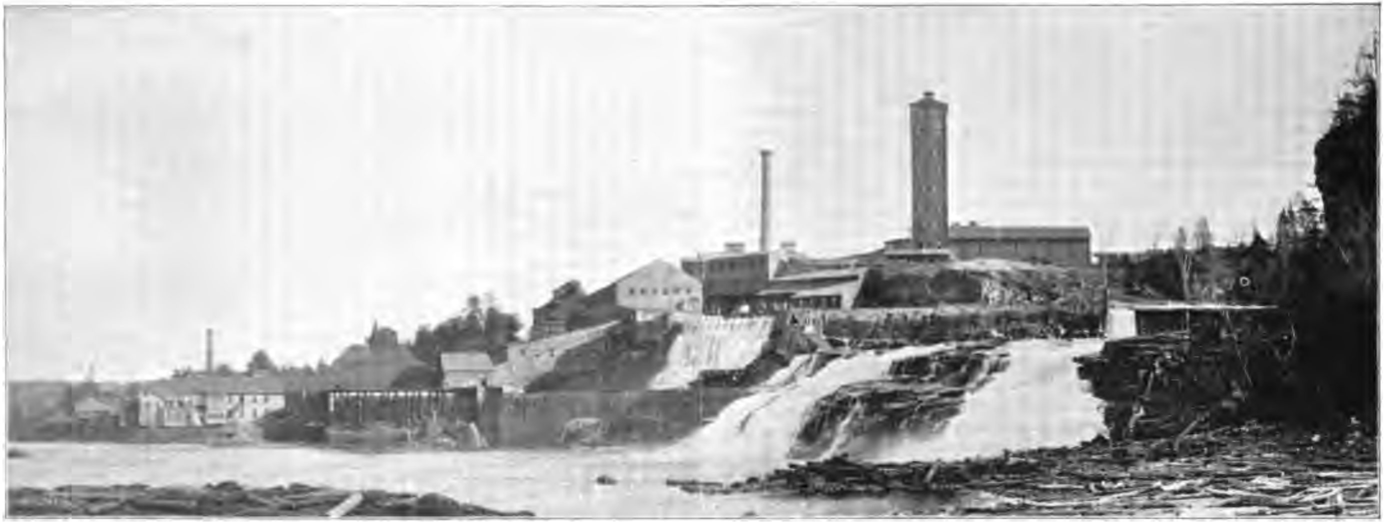


PLATE DD.—A GENERAL VIEW OF THE WATER POWER DEVELOPMENT AT PALMER'S FALLS.
The overflow from the upper raceway may be seen in the middle of the picture.

In any case, the day has passed when the State in its sovereign capacity can, without loss of dignity, simply say, this stream is State property, to be held and even disposed of absolutely without reference to the wants or wishes of the riparian proprietors.

These interesting problems are, therefore, presented for consideration, in the belief that the Legislature in its wisdom will arrive at a solution, which, while protecting whatever rights the State may justly retain, will still in no way interfere with the full development of manufacturing enterprise on the stream.

CONCLUSIONS.

In drawing a series of conclusions from the foregoing discussion it may again be remarked, that by reason of incompleteness of the data some of the conclusions are necessarily tentative, and subject to modification if more extended data should indicate any essential error in the present discussion. In any case, the foregoing is the best the undersigned is capable of doing in the time available and with the material at hand. With this understanding we may say:

(1.) It is entirely feasible to construct a system of reservoirs in the Upper Hudson valley.

(2.) Said system may be designed with reference to the full capacity storage of at least 1,200 square miles of area.

(3.) The total area above Glens Falls is 2,800 square miles, of which 1,200 square miles the area controllable to full capacity is forty-three per cent. Hence such control will result in material reduction of floods at Glens Falls and other points.

(4.) For present purposes the total storage may be placed at 41,593,000,000 cubic feet.

(5.) The Mechanicville gagings give us definite information as to the regimen of the stream for eight years.

(6.) The proposed total storage of 41,593,000,000 cubic feet would maintain 4,500 cubic feet per second flow, as well as supply the other necessary demands, in the driest season of the eight year period.

(7.) The gagings show that, whereas the minimum unregulated flow at Glens Falls is as low as 900 cubic feet per second for a monthly mean, with the storage carried out, we may expect at least 3,000 to 3,600 cubic feet per second as the monthly mean flow at Glens Falls.

(8.) The minimum regulated flow of 4,500 cubic feet per second at Mechanicville will increase the low water depth in the Hudson river at Albany about 1.5 feet.

(9.) The leakage of the Glens Falls feeder is a great injury to the water power at Glens Falls.

(10.) The legitimate diversion for the use of the Champlain canal, both present and prospective, is also an injury to the water power at Glens Falls and lower points on the river.

(11.) Water power is much cheaper than steam power; hence the taking of the water of the river away from the manufacturers is to them a serious matter.

(12.) In the thirteen years from 1882 to 1895, the use of water power on the Hudson river has increased from a total of 12,894 net horse power in 1882, to 43,481 net horse power in 1895; an increase of 237 per cent.

(13.) Taking into account the capitalized value of the several benefits to be derived from the Upper Hudson storage and we reach the grand total of $38,019,528.

(14.) The reservoir system is estimated to cost $2,606,559. This sum includes clearing below the flow line, roads about the reservoirs, and the providing of logways and fishways.

(15.) The Upper Hudson storage system is also estimated to cost $62.69 per million cubic feet stored, which is found to be considerably less than the cost of many other systems.

(16.) By clearing all timber below the flow lines and by the construction of roads around the lakes, this reservoir system can be made an attractive feature of the proposed Adirondack park.

(17.) The reservoirs will exert a beneficial effect on the fisheries.

(18.) Similar reservoir systems carried out on the Upper Mississippi river have been of great benefit to navigation and the other interests.

(19.) In New England vast benefits to the manufacturing interests have resulted from the construction of storage reservoirs for water power purely.

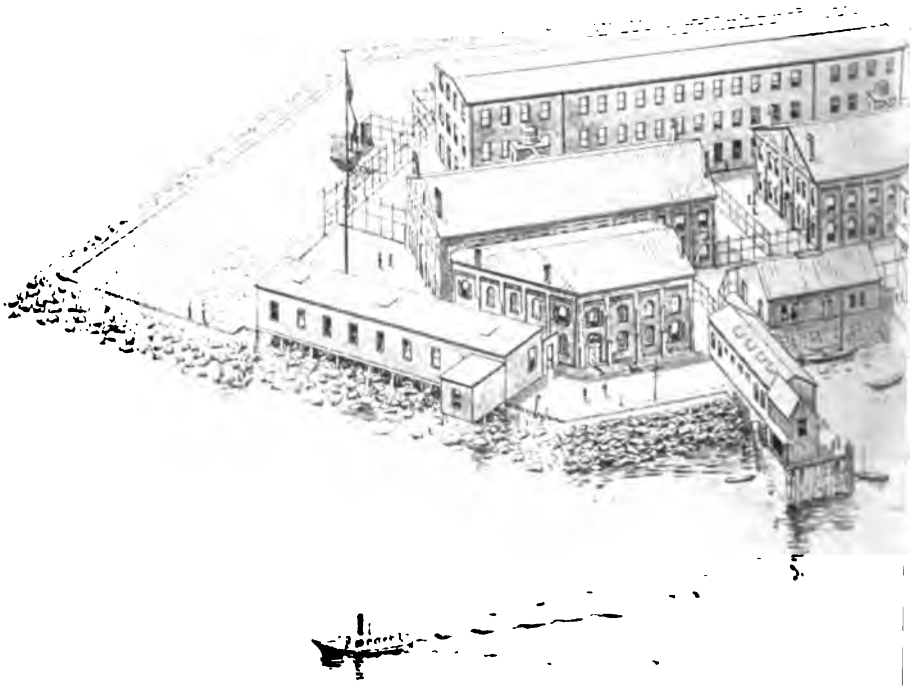
(20.) The State owns the Hudson river, but such ownership carries with it the responsibility of acting in some direction.

Hoping, gentlemen, that the foregoing will furnish to the Legislature a portion, at any rate, of the information called for by Chapter 599, I am,

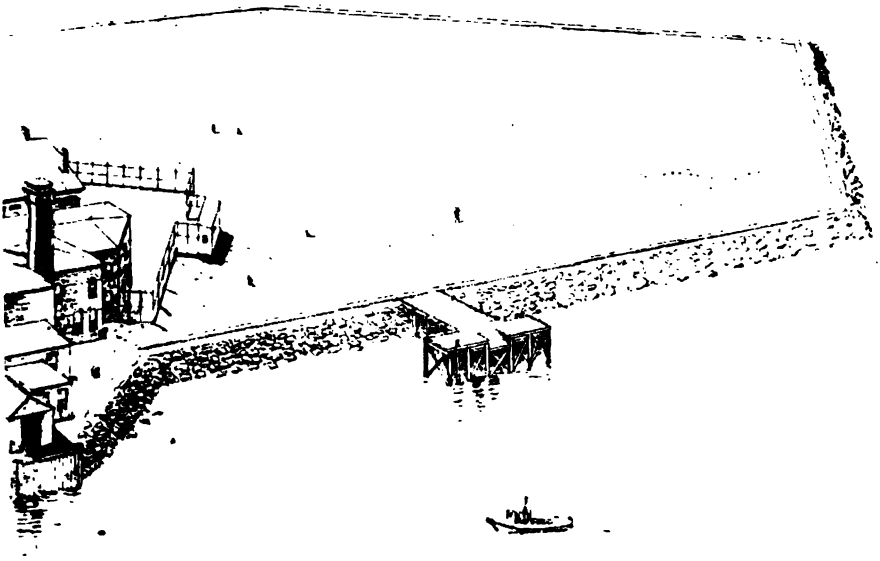
Very respectfully,

GEO. W. RAFTER,

Engineer-in-Charge.



Birdseye View of Hoffma



nd Showing Enlargement.

ENLARGEMENT

OF

HOFFMAN ISLAND.

Enlargement of Hoffman Island.

Act, chapter 486, Laws of 1894, directs that the moneys appropriated for this work shall be expended under the direction of a special board of commissioners, created by chapter 270 of the Laws of 1888, consisting of the mayor of the city of New York, the mayor of the city of Brooklyn, the State Engineer and Surveyor, the quarantine commissioners and the health officer of the State of New York; also that all work shall be done in accordance with plans, specifications and estimates prepared by the State Engineer and Surveyor.

During the years 1894 and 1895, the Legislature made the following appropriations for this improvement:

By act, chapter 486, Laws of 1894	$160,000
By act, chapter 932, Laws of 1895	75,000
Total	$235,000

The act of 1894 made the sum of $50,000 available up to June 1, 1895, and the balance of the amount appropriated ($110,000) available on and after that date.

The estimated cost of completing the enlargement, which included the cost of surfacing the enlarged portion with a covering of cinders, concrete and American Portland cement, and not including the expenses of engineering and incidentals, amounted to about $260,000.

Plans, specifications and estimates were prepared by the State Engineer and Surveyor, and at a letting held August 4th, 1894, at the office of the board of commissioners, 71 Broadway, New York, the contract was awarded to P. Sanford Ross of Jersey City, N. J., for partially completing the proposed enlargement as far as the appropriation ($160,000) of the Laws of 1894 would admit.

The following statement shows the estimated amount of work to be done and the cost of the same at contract prices, with the amount appropriated ($160,000) by chapter 486, Laws of 1894.

Estimated cost of the partial enlargement of Hoffman Island, New York harbor, in accordance with the terms of the contract dated September 4, 1894, of P. Sanford Ross, contractor, with the people of the State of New York.

Chap. 486, Laws of 1894.

Quantities	ITEMS.	Contract price.	Amounts.
104,800	Cubic yards embankment	$0 28	$29,344 00
1,800	Cubic yards excavation of old rip-rap	2 50	4,500 00
5,000	Cubic yards stone fillings in cribs	83	4,150 00
28,800	Cubic yards rip-rap stone in place	83	23,904 00
10	Cubic yards American Portland cement concrete	7 00	70 00
900	Cubic yards coursed Ashlar masonry, including coping in American Portland cement mortar	14 00	12,600 00
2,350	Cubic yards coursed rubble masonry in American Portland cement mortar	5 75	13,512 50
1,163,000	Feet B. M. Southern pine timber and plank, per M	29 00	33,727 00
69,100	Pounds wrought iron	3½	2.418 50
7 1-2	Gross tons cast iron. Per gross ton	35 00	262 50
1,000	Pounds spikes and nails	3½	35 00
1	Removing outhouse and platforms	500 00	500 00
			$125,023 50
	Deduct materials furnished by State:		
2,000	Cubic yards old rip-rap stone	. 75	1,500 00
			$123,523 50

Work under this contract began September 26, 1894. The expense to the State having been increased several thousand dollars, owing to the fact that the revision of the enlargement plans to suit the appropriation made by chapter 486, Laws of 1894, made it necessary to increase the amount of wall and rip-rap and construct the same as a protection to the work in a location where it would be of no use when the enlargement was completed.

The additional sum of $75,000, appropriated by act, chapter 932, Laws of 1895, for completing the enlargement except the top surfacing of the new work, became available June 5th, 1895. Under the clause of this contract, "Alterations, and directions to be complied with and quantities increased or diminished," the board of commissioners directed the plans to be revised and the

quantities of work be increased to the extent required to complete the enlargement, not including the expense of finishing the top surface of the new work with a covering of cinders, concrete and Portland cement.

By the terms of the contract dated September 4th, 1894, any increase in the several quantities or work shall be paid for at the prices stipulated in the contract for the same class of work, but it was found that the funds available ($235,000) would, when applied to the estimated quantities at contract prices, suffice for all the work contemplated except the embankment, which could not be carried up to the desired height.

In order that the enlargement might be completed ready for the building foundations and the top surfacing, the contractor, P. Sanford Ross, entered in a supplemental contract, June 26, 1895, with the board of commissioners to this effect:

All work to be done in accordance with the article of agreement made and concluded the fourth day of September, 1894, between P. Sanford Ross and the people of the State of New York, represented by the board of commissioners created under chapter 270 of the Laws of 1888 for the enlargement of Hoffman Island, and in accordance with the plans and specifications exhibited at the letting of said work, except that the top elevations of all embankment shall be lowered to the elevation 97.00 and the price of the embankment on the southerly portion of the new work, from the elevation 81.80 to the elevation 97.00, shall be furnished and placed in the work at the rate of twenty-one (21) cents per cubic yard; and the top elevation of the crib work and the bottom elevation of the rubble wall shall be raised to the elevation 83.80, as shown on page of diagram, etc., etc.

The total cost of the proposed complete enlargement, based on the quantities estimated at prices stipulated in the contract dated September 4, 1894, and on the reduced price per cubic yard for embankment, per supplemental contract of June 26, 1895, is shown by the following statement:

Estimated cost of the complete enlargement of Hoffman Island, New York harbor, in accordance with the terms of the contracts, dated September 4, 1894, and June 26, 1895, P. Sanford Ross, contractor.

The top surfacing and tee landing are not included.

Chap. 486, Laws of 1894, and chap. 932, Laws of 1895.

Quantities	ITEMS.	Contract prices of 1894.	Contract prices of 1895.	Amounts.
101,473	Cubic yards embankment	$0 28		$28,412 44
135,134	Cubic yards embankment		$0 21	28,378 14
1,862	Cubic yards excavation of old rip-rap	2 50		4,655 00
6,080	Cubic yards stone filling in cribs	83		5,046 00
48,230	Cubic yards rip-rap stone in place	83		40,030 90
2,445	Cubic yards coursed Ashlar masonry, including coping, in American Portland cement	14 00		34,230 00
5.112	Cubic yards coursed rubble masonry, in American Portland cement	5 75		29,394 00
1,378,000	Feet B. M. Southern pine timber, per M	29 00		39,962 00
102,200	Pounds wrought iron	3½		3,577 00
30	Gross tons cast iron, per gross ton	35 00		1,050 00
1	Removing outhouse and platforms	500 00		500 00
				$215,235 88
	Deduct materials furnished by State:			
1,672	Cubic yards old rip-rap stone	75		1,254 00
	Total			$213,981 88

HOFFMAN ISLAND ENLARGEMENT, DESCRIPTION OF WORK.

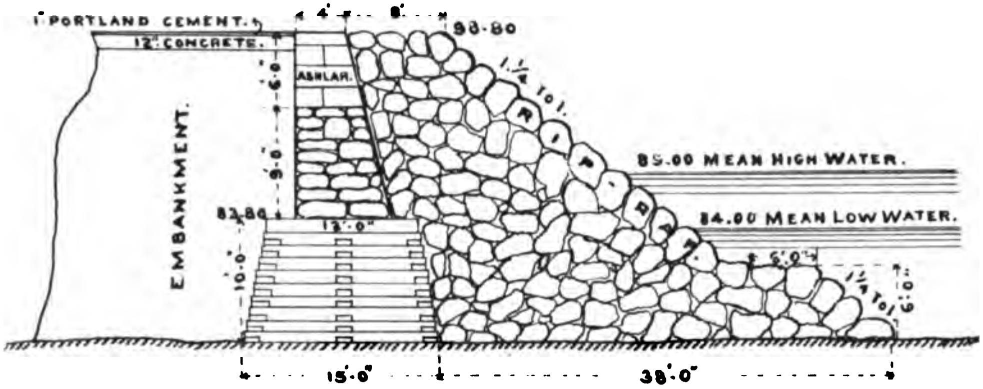
The present island, having an area of 2.59 acres, is to be extended to the eastward 150 feet and southward 600 feet, so that the total area of the old and new portions will be 9.92 acres. This does not include the rip-rap.

The enlarged portion is to be surrounded by a tight crib of southern pine timber, filled with stone, and a masonry wall laid in Portland cement mortar. The crib and wall are to be protected on the outside by heavy rip-rap of the following section: Top width, eight feet; face slope, one and one-quarter feet horizontal to one foot vertical.

The crib work, constructed of 12″ x 12″ longitudinal timbers, and 10″ x 12″ cross ties, all squared timber and laid close, is to have a top width of twelve feet, with a front and rear batter of 2″ x 12″.

The deck is to be of 12″ x 12″ timbers and to be placed at the elevation of mean low water.

F



HOFFMAN ISLAND.

Section of completcd Island.

Scale 1 in. = 16 ft.

JY. FEB. 1896.

After the cribs are completed in place, a masonry wall four feet wide on top, with a front batter of 3″ × 12″, and a vertical back, is to be placed on the deck. This wall will be fifteen feet high; the top elevation to be the same as the top elevation of the present island on its outer edge, and will be covered by a cut stone coping four feet wide and twelve inches thick.

From the lower side of the coping to a level five feet below, the wall is to be of cut ashlar masonry, and from this level to the deck of the crib, of coursed rubble masonry.

All masonry is to be laid in a mortar composed of three parts of sand to one part of American Portland cement.

The enlarged portion inclosed by the crib and wall will be filled with material taken by pump dredges from the shoals about the island.

Pipes will be laid through the wall and rip-rap for sewer connections. Manholes and catch basins will be constructed where necessary.

After the beginning of the enlargement work it was considered to be necessary to construct a pile landing pier on the west side of the southerly enlarged portion of the island, in order to provide a way for keeping the detained cabin and steerage passengers separated. This landing has been constructed during the year.

The stairway landing in the slip of the present island was found to be worn out and in a dangerous condition, and has been rebuilt in a new location, thereby increasing the amount of space in the slip for the health officers' boats when landing passengers from quarantined vessels.

The cost of these improvements are included in the monthly estimates of work done, and have increased the cost of the enlargement about $3,000.

The following statement, arranged by months, from the beginning of the work, gives the amount of work done by the contractor, the percentages retained, the amounts of payments or amounts due, and also the expenditures for printing and advertising up to October 1, 1895.

Month.	Year.	Total amount of work done.	Percentages retained.	Amount of payment.
October	1894	$8,400	$1,260	$7,140
November	"	9,740	1,461	8,279
December	"	3,940	591	3,349
January	1895	6,160	924	5,236
February	"	2,300	345	1,955
March	"	6,040	906	5,134
April	"	7,100	1,065	6,035
May	"	6,280	942	5,338
June	"	3,500	525	2,975
July	"	12,940	1,941	10,999
Aug. and to Sept. 13	"	7,680	1,152	6,528
Sept. 13 to Oct. 1	"	12,060	1,809	10,251
Totals		$86,140	$12,921	$73,219

FOR PRINTING AND ADVERTISING.

	Printing.	Advertising
September 19 to December 31, 1894	$49 30	$140 80
January 1 to March 1, 1895	18 00	
Totals	$67 30	$140 80

The construction work, including inspection of the enlargement, has been in the charge of a corps of engineers from the Department of the State Engineer and Surveyor. The salaries and expenses of the engineers have been paid out of the sums appropriated for the enlargement.

The following monthly statement shows the total expenditures for this purpose and also for engineering supplies and board of engineers on the island up to October 1, 1895.

For the month of	Year.	Salaries, expenses and board.	Engineering supplies.	Remarks.
Sept. 19 to Dec. 31..	1894	$2,413 94	$24 40	
Jan. 1 to April 1...	1895	1,972 43	7 60	
April 1 to July 1...	"	2,314 59		
July 1 to Oct. 1....	"	2,439 11		
Totals.		$9,140 07	$32 00	

Summary of the total cost of the work, engineering, etc., from the beginning of the enlargement up to October 1, 1895.

ITEMS.	Total liabilities up to October 1, 1895.	Amounts paid up to October 1, 1895	Amounts remaining due October 1, 1895.	Remarks.
Contract work..................	$86,140 00	$73,219 00	$12,921 00	15% retained.
Printing..........................	67 30	67 30	....	
Advertising	140 80	140 80	....	
Engineering, salaries, etc......	9,140 07	9,140 07	....	
Engineers' supplies............	32 00	32 00	....	
Totals......................	$95 520 17	$82,599 17	$12,921 00	

PROGRESS OF WORK UP TO OCTOBER 1, 1895.

The following statement shows the total amount of the different items of work done from the beginning of the enlargement up to October 1, 1895; also the cost of the same at contract prices.

For work done and material furnished up to October 1, 1895, by P. Sanford Ross, contractor, under his contracts dated the fourth day of September, 1894, and the twenty-sixth day of June, 1895, for the enlargement of Hoffman Island, New York harbor. Chap. 486, Laws of 1894, chap. 932, Laws of 1895.

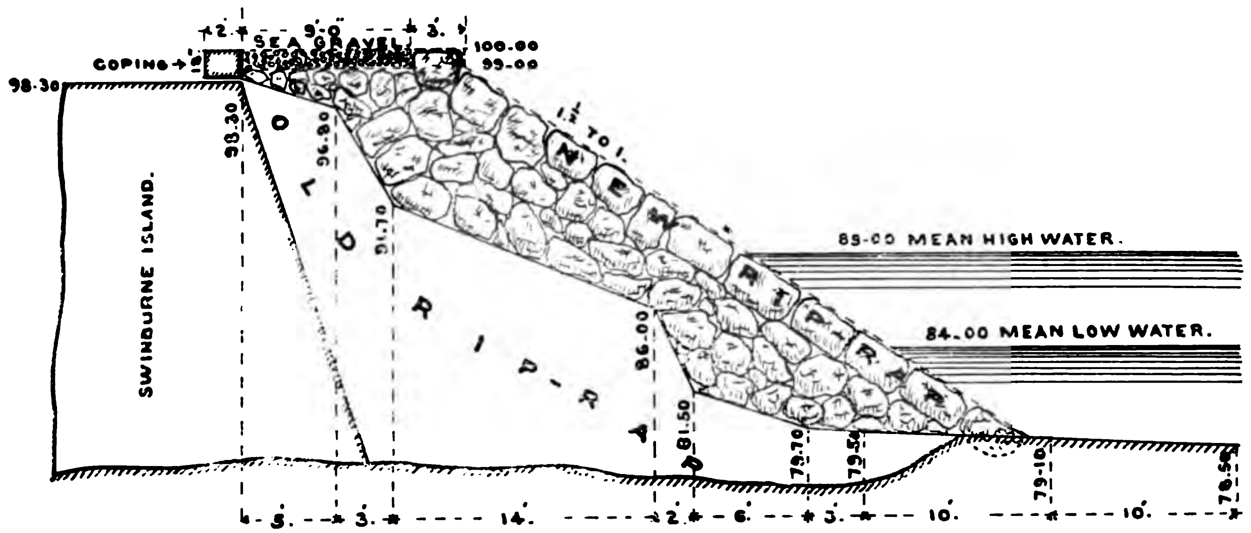
Quantities	ITEMS.	Contract price.	Rel. price.	Amounts.	
6,100	Cubic yards embankment	$0 28		$1,708 00	
2,119	Cubic yards excavation of old rip-rap	2 50		5,297 50	
6,100	Cubic yards stone filling in cribs...	83		5,063 00	
29,800	Cubic yards rip-rap stone in place...	83		24,734 00	
1,112	Cubic yards coursed rubble masonry in American Portland cement......	5 75		6,394 00	
29	Cubic yards American Portland cement concrete	7 00		203 00	
1,334,000	Feet B. M. Southern pine timber in place, per M......................	29 00		38,686 00	
92,800	Pounds wrought iron, per pound....	3½		3,248 00	
1.35	Gross tons cast iron, per gross ton..	35 00		47 25	
					$85,380 75
	Extra Work.				
	For labor, materials and necessary expenses for taking up and relaying salt water pipe, not covered by contract.				
	For labor			$41 00	
	For pipe, elbows, flanges, etc........			53 05	
	For expenses, board of men, cartage, etc.			14 45	108 50
	Contract:				
	For Tee landing, not covered by				
3,120	Lin. ft. white oak piles driven, per linear ft.		$0 40	$1,248 00	
26,000	Ft. B. M., Southern pine timber in place, per M......................		32 50	845 00	2,093 00
					$87,582 25
	Deduct materials furnished by State:				
1,929	Cubic yards old rip-rap stone........	75		$1,446 75	1,446 75
	Total estimate to date				$86,135 50
	Total estimate, say				$86,140 00
	Fifteen per cent. retained				12,921 00
	Amount paid				$73,219 00

REPAIRS TO RIP-RAP ON SWINBURNE ISLAND.

Act, chapter 932 of the Laws of 1895, appropriates $10,000 for repairs to rip-rap on Swinburne Island, to be expended under the direction of the board of commissioners, created by act, chapter 270 of the Laws of 1888.

Plans, specifications and estimates were prepared by the State Engineer and Surveyor, and at a letting held September 13, 1895, at the office of the board of commissioners, 71 Broadway, New York, the contract for making said repairs was awarded to P. Sanford Ross, of Jersey City, N. J. The contract was executed

D.



SWINBURNE ISLAND

Section showing proposed repairs.

Scale 1 in. = 10 ft.

JY. FEB. 1896.

September 26, 1895, for the following quantities and items of work, and for the following prices:

Quantities	ITEMS	Prices.	Amounts
400	Cubic yards broken stone or sea gravel in place..........	$1 50	$600 00
5,500	Cubic yards rip-rap stone in place..........................	92½	5,087 50
25	Cubic yards American Portland cement concrete.........	10 00	250 00
133	Cubic yards stone coping, in place	15 00	1,995 00
	Total		$7,932 50

REPAIRS TO RIP-RAP ON SWINBURNE ISLAND.

Description of Work.

Hoffman and Swinburne Islands are built upon sand bars and are subject to the action of the severe storms which occur in the lower bay; their only dependence for existence is upon the protection afforded by the rip-rap embankment which has been placed around them.

At Swinburne Island this rip-rap embankment has been undermined by the action of the waves and has settled to such an extent as to endanger the safety of the island.

The present elevation of the top surface of the island is too low, and during storms the easterly side is frequently submerged.

It is proposed to reinforce the island by means of rip-rap and stone coping, which will be carried up to an elevation two feet higher than the present top surface of the island proper.

The entire outer edge of the present island is to be coped with granite or limestone, forming a stone parapet two feet high and two feet wide. In front of this parapet the old rip-rap will be strengthened by additional rip-rap, which will be carried up to an elevation one foot below the top of the stone coping; it will be twelve feet wide on top and have a face slope of one and one-half feet horizontal to one foot vertical.

The top surface of this twelve foot width of rip-rap is to be leveled off and covered with a twelve inch layer of broken stone or coarse sea gravel. This finish will not only add to the fine appearance of the island, but will also render available, around the entire island, an additional space twelve feet wide, and will increase the area considerably.

AREA OF SWINBURNE ISLAND, RIP-RAP NOT INCLUDED.

Island proper	2.015	acres
Breakwater	0.141	"
Tee landing	0.215	"
Total	2.371	"

HOFFMAN AND SWINBURNE ISLANDS.—FRESH-WATER SUPPLY.

The sum of $8,000 appropriated by act, chapter 358 of the Laws of 1894, is insufficient to lay a fresh-water pipe line from Staten Island to Hoffman and Swinburne Islands.

The main line would require more than two miles of four and six inch pipe, and all of it to be laid under water.

It is possible that a supply can be obtained by means of driven wells. Professor Hall, State Geologist, has made inquiries and given the matter some consideration. He thinks fresh-water can be obtained in sufficient quantities at a depth of 500 feet.

It is recommended that the sum of $8,000, appropriated by chapter 358, Laws of 1894, be reappropriated, and that an additional sum of $20,000 be appropriated, all to be available for the purpose of obtaining a supply of fresh-water for both islands; and also, that the board of commissioners be authorized to expend from the total ($28,000) a sum not to exceed $5,000, to drive a test well or wells on Hoffman or on Swinburne Island, or on both, and if this plan should be a success, have authority to use as much of the total sum of $28,000 as would be necessary to obtain the required supply by this plan, and if it should not be a success, abandon the driven well plan and with the funds available ($23,000) proceed to obtain a supply by means of a pipe line from Staten Island.

TOWING BY ELECTRICITY.

Towing by Electricity.

Reference was made in my report for the year of 1894, to the use of electricity on the canals, and the hope expressed that the same might soon be made applicable to the propulsion of canal boats. A description accompanied by cuts was given of the device of Mr. Milligan, which appeared to be one step, at least, toward the accomplishment of the desired end. Since the publication of that report, another and much more important step has been taken, namely, a practical test of an electric motor, the invention of Mr. Richard Lamb. This test took place on the 26th of October, 1895, in the village of Tonawanda, a location decided on as it combined nearly all the problems to be encountered in towing on the canals, namely, tangents, curves and bridges. The accompanying photographs taken at the time of the trial will help to explain the following technical description of the device.

Brackets are erected upon posts or supports placed 125 feet apart, with saddles placed upon the brackets, having insulated material between them. The saddles are designed to prevent short circuiting of the electric current by rain.

A bracket is also provided to support the lower or traction cable. This is not insulated, but at intervals along the line some of these brackets are grounded. A one and one-quarter inch steel cable is supported upon the upper saddles and a five-eighth inch steel cable upon the lower.

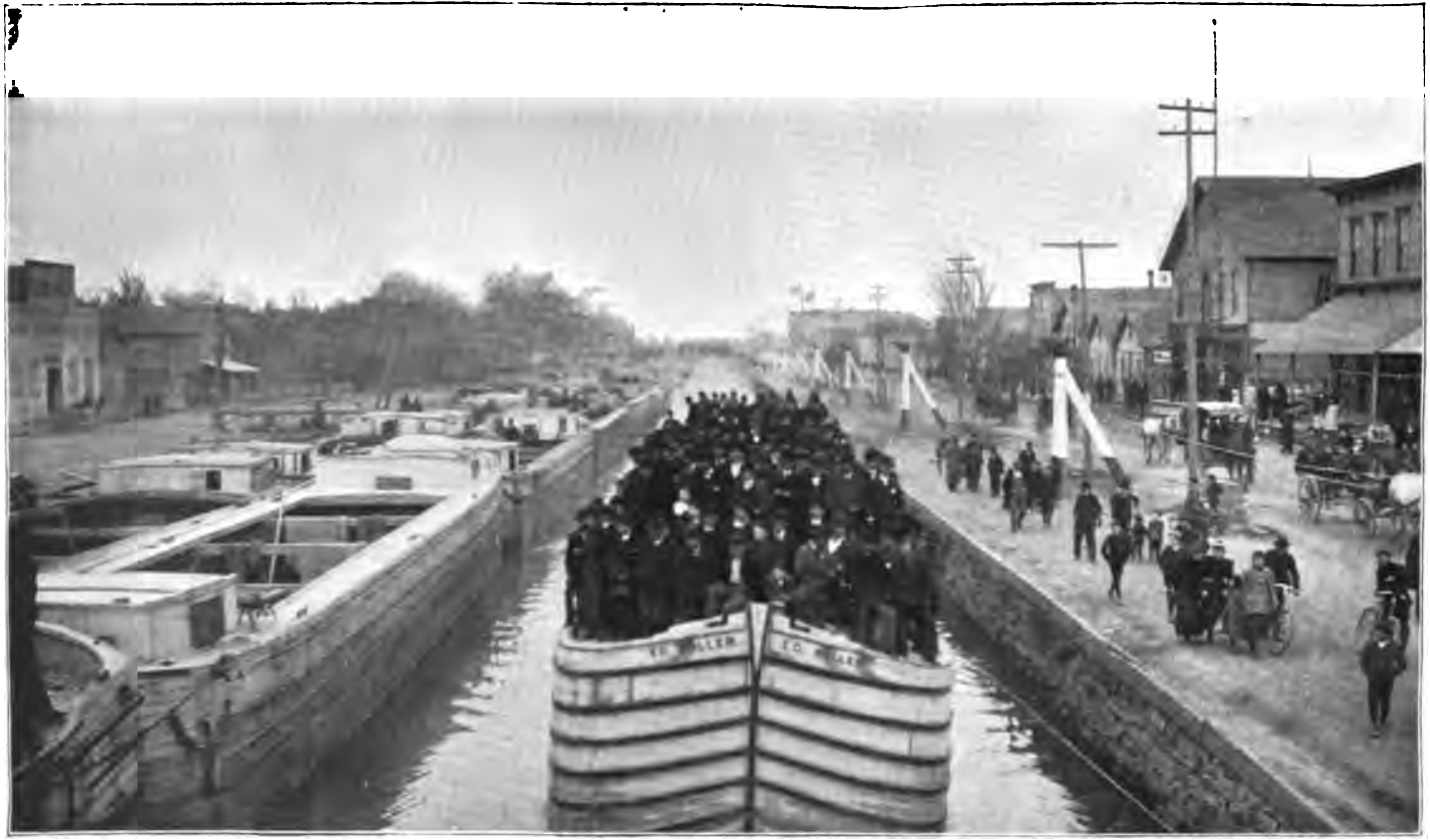
In canal boat towing, the cable line is placed upon the inward side of the towing path, the bearing cable is placed at an elevation of sixteen feet from the ground, and the traction cable three feet below it.

The motor truck is made with two deep grooved wheels to run on a cable having horizontal axles between them and below their centre line. Upon the axle is suspended a hanging frame, having attached to it an elliptical grooved sheave, which is revolved by a worm or wedge gearing, driven by a fifteen Kilowatt electric motor with vertical shaft, all attached to the swinging frame of the car. By taking three turns of a five-eighth inch cable around the elliptical grooved sheave, when the electric motor revolves the gearing, the sheave winds up, and at the same time pays out on the five-eighths inch cable, thus pulling along the car. The motor in this way gets its tractional friction independent of the weight of the apparatus. The current is returned through the traction cable, which is grounded at intervals, giving a combined ground and metallic conductor for the return current. A 500 volt current was used. It is taken from the main cable through the wheels, thence through the axle to the axle box of the hanging frame. Here an insulated copper wire connects it with the rheostat. The return current is passed through the axle of the elliptical-grooved wheel, thence on to the five-eighths wire to the brackets; thence through a wire to the ground; thence to the pole of the generator.

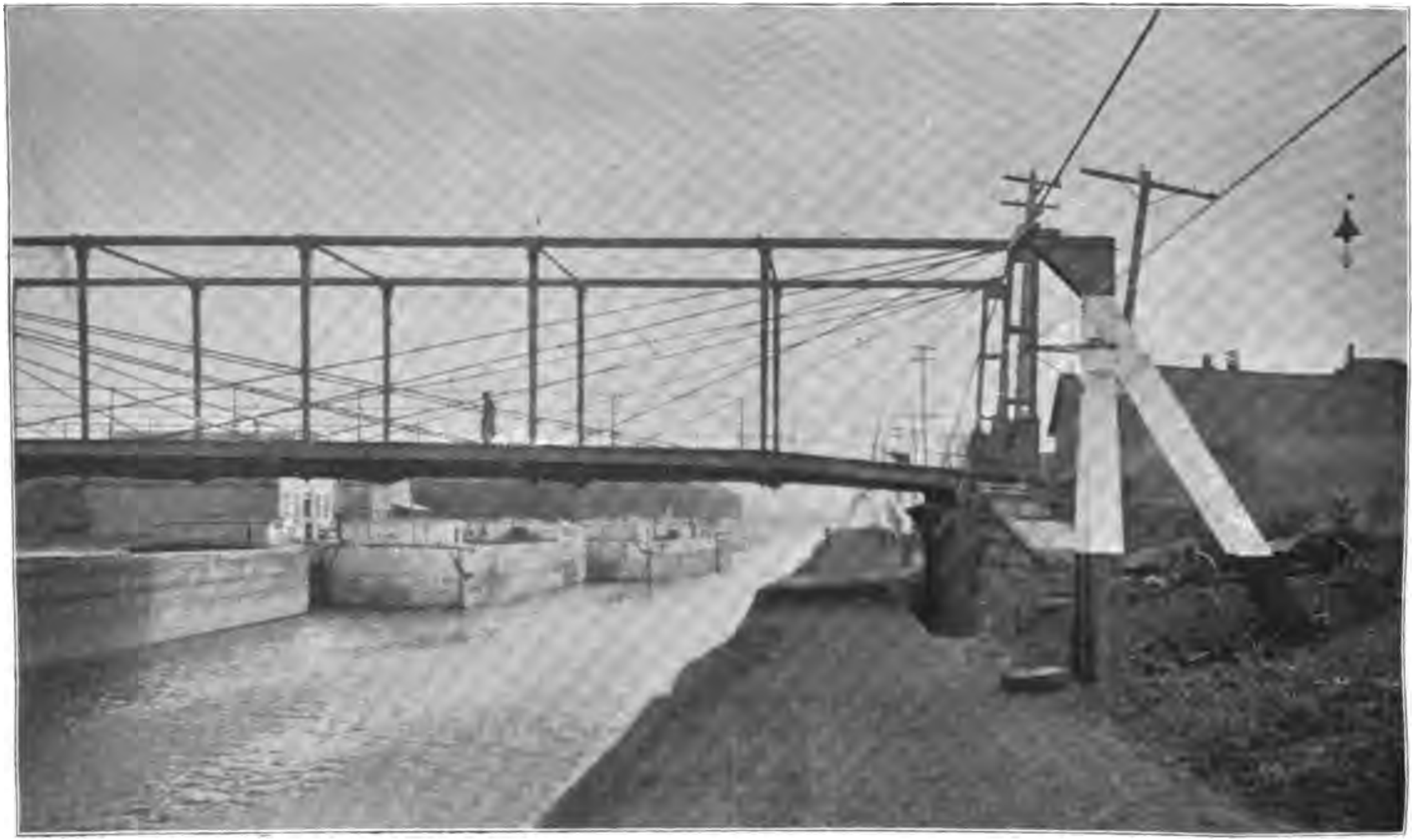
When the motor reaches the bracket, the traction cable is lifted from the saddle momentarily and the car can take a new course. Hence, it is not limited to operating in a straight line. The saddles are made so that the wheels leave the cable and ride over on their flanges in the channels of the saddles, made for a straight line or right and left deflections. The main cable is used as the electrical conductor.

It is insulated at the brackets, by insulating material placed between the saddle and the bracket and the current is prevented from passing down the frame of the motor by insulation at the point on the frame where the axle box joins the frame proper. The points of insulation are provided in their construction with hoods, to shed water.

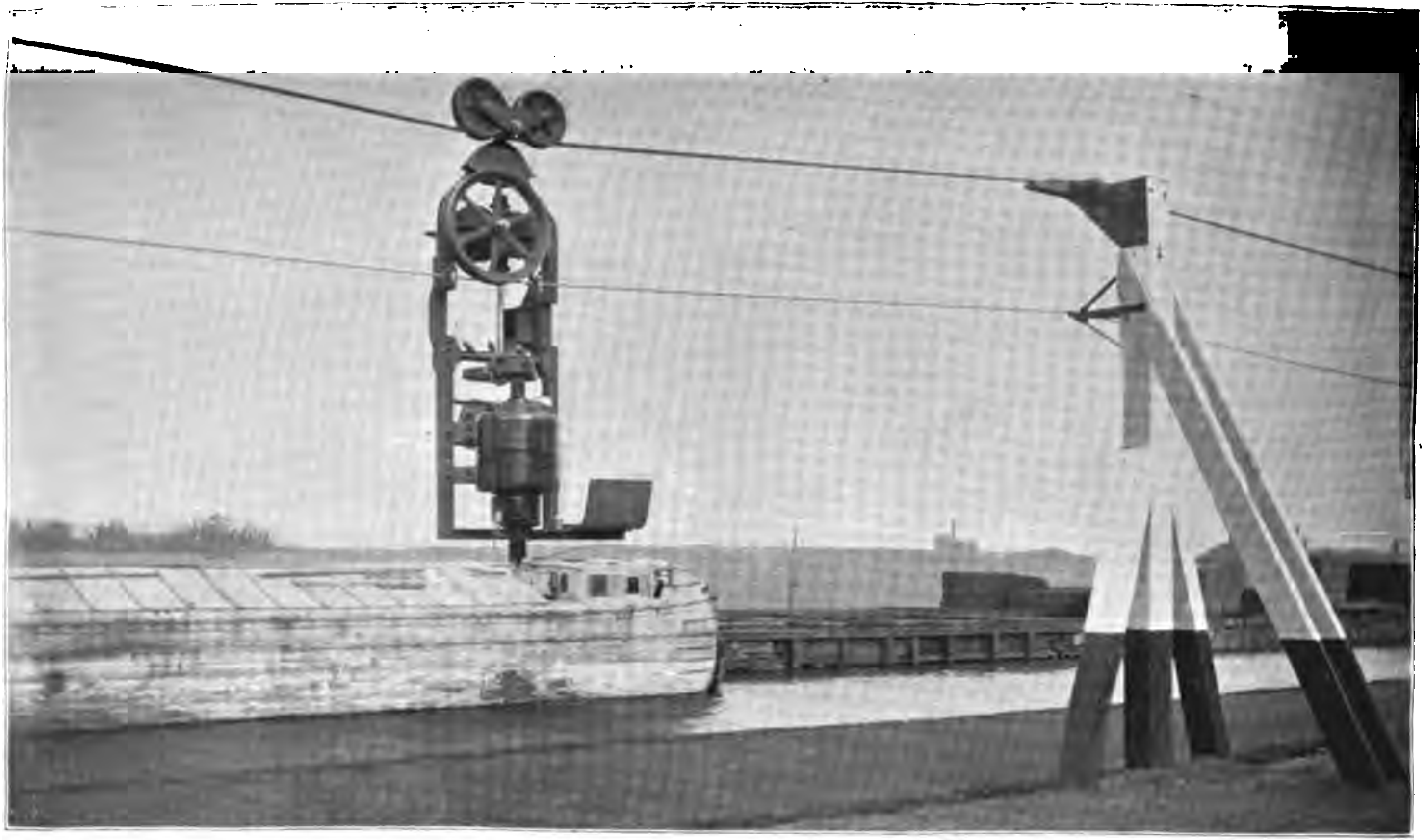
The worm or wedge gear used differs from the ordinary worm gear, in that it has more than twenty times the bearing surface of an ordinary worm and wheel, moves two teeth of the gear wheel at each revolution of the worm, and works on the principle



Lamb Electrical Towing System.
(Boat with officials being towed by Motor on Saturday, October 26, 1895, at Tonawanda, N. Y.)



LAMB TOWING SYSTEM.
(Showing descent of Cable under a Bridge.)



Lamb Towing System. Motor, Cable and Supports.

of a wedge, rather than an inclined plane. The worm gear especially made for this motor, is designed to work both ways, and has ball bearings at either end of the worm to lessen the friction and thrust.

The gear wheel, worm and ball bearings are incased in a jacket filled with oil. Thus the minimum loss in power is effected between the electric motor and elliptical grooved wheel.

The gearing was necessary, in order to lessen the speed, as the electric motor is run at 1,840 revolutions per minute. The rheostat is made to carry the current through it, as well as to regulate the speed and reverse the current, and has an automatic switch. Four insulated copper wires, armored with steel wire, form the cable that conducts the electricity from the bearing cable to the rheostat on the boat and back to the motor, and at the same time acts as the tow-line. The upper end is clamped to a ring that runs on a traveler situated on the frame of the motor about the lower part of the elliptical grooved wheel. A long steel clamp with toggle joints is used to hold the towing cable at any point desired, and has a ring in one end, to which is attached a short length of rope, which is made fast to the Samson post of the boat. The end of the towing cable is carried to the rheostat on the boat, where it is coupled to a similar piece of cable wired to the terminals of the rheostat. The coupler is designed so that it is impossible to join others than the right wires together, and the contact is made quickly and securely. When a motor is to be run without any boats in tow, its rheostat and conducting wire tow line is placed upon the motor, and a driver seated on a seat on the electric motor, operates the same.

On this occasion the motor was attached to a light canal boat ninety-six feet long by seventeen feet ten inches beam, crowded with interested officials and invited guests, but no other load. The constructed line was 1.23 miles in length and this boat was towed the entire length against the wind and current in twenty-one minutes, making a speed of 3 3-5 miles per hour. Going back, five light boats of the same dimensions were towed with the current, in twenty-two minutes, giving practically the same ratio of speed.

This test demonstrated that the motor should be built in more compact shape to facilitate its passage under bridges, a defect easily remedied, but whether the same is commercially valuable as against steam at the present time, will depend largely on the cost of producing the electric current, and the cost of erecting and maintaining the poles and wires. It costs not less than five cents per hour by steam power, or $17.60 from Buffalo to Albany. This is based on twenty horse power per boat, which was the amount required to tow six Cleveland steel canal boats at the rate of three miles an hour. Horse or mule power for boat propulsion in the Erie canal costs not less than twelve cents an hour, or $42.24 per boat for the 352 miles from Buffalo to Albany. In the absence of actual figures for the cost of electricity, it will be seen that the comparisons will depend on those figures, which will be difficult to deduce from this experimental test.

Chapter 219 of the Laws of 1895 provided the necessary means for the collection of such data as might be valuable as a result of this test, under the joint supervision of the Superintendent of Public Works and State Engineer and Surveyor. After due consideration, it was decided to place this work in the hands of an electrical expert for an investigation and report, and Mr. C. R. Barnes, of Rochester, was accordingly selected. His report follows:

OFFICE OF
C R. BARNES, ELECTRICIAN,
ROCHESTER, N. Y., *December* 11, 1895.

Hon. GEORGE W. ALDRIDGE, *Superintendent of Public Works*,
and Hon. CAMPBELL W. ADAMS, *State Engineer and Surveyor*,
Albany, *N. Y.*:

Dear Sir — In accordance with your instructions, I have carefully investigated and tested the electric towing system constructed and operated by the Erie Canal Traction Company at Tonawanda.

This system is known as the Lamb electric towing system, and consists, essentially, of a stationary cableway supported by a line of poles along the canal bank, and electric-motor carriages traveling thereon and towing boat or boats attached thereto.

In the experimental plant and equipment examined, the cableway comprised a line, one and one-quarter miles in length, of poles sixteen feet high above ground and well braced to withstand lateral strain. These poles were placed 125 feet apart and each carried two iron brackets, one mounted on top of pole and one three feet below, which were provided with suitable saddles for the cables to rest in, the upper line of saddles being electrically insulated from the brackets. The upper line of brackets carried a cable one and one-quarter inches in diameter, while a five-eighth inch cable was suspended upon the lower line. The tow motor consisted of a twenty-two horse-power electric motor of the Story type, attached to a little truck having two grooved wheels, placed in tandem, in such manner that it would hang and travel on the upper cable. The motor armature was geared to a grooved sheave twenty inches in diameter, around which the lower cable had been given three turns and by this means the motor could be propelled, the cable being wound up forward and at the same time paid out behind. The electric current necessary for the operation was conducted along the upper (insulated) cable to the motor truck, thence through the controlling switch and rheostat to the motor armature, after leaving which it passed on to the lower (traction) cable, returning to the source of electricity partly through this cable and partly through the ground to which the latter was suitably connected. Thus the upper cable served both as an electric conductor and a support for the tow motor, while the lower cable afforded the necessary tractive medium and return conductor. The motor truck was provided with a seat upon which the man operating the motor was located. A tow-line connected the motor with the boat. In reference to this last-mentioned feature it should be added that it is proposed in practice to place the controlling device upon the boat itself and to use a metallic tow-line to electrically connect the motor with the controlling device, in order that the steersman may operate the motor himself, thus doing away with the motorman.

A public exhibition of the system was given October 26, 1895. A canal boat loaded to full capacity was towed up against the current, and a train of five ordinary canal boats loaded with people was towed on the return trip. This exhibition was witnessed by ex-Governor Flower, the Superintendent of Public Works, the State Engineer and other officers of the Canal Department, and a large number of interested boat owners, and all present appeared well pleased with the operation of the system. Following this public exhibition I have, with the assistance of competent electrical engineers, made a series of careful tests extending over a period of several weeks, the results of which in tabulated form are hereto attached. The tables show the readings of electrical measuring instruments taken at intervals of fifteen seconds, and the power and speed data computed therefrom. For the purpose of these tests, the State scow "Tonawanda" had been used and towed up and down the experimental section a number of times under varying conditions of wind and current. The "Tonawanda" weighed sixty tons, carried a load of 157½ tons, making a total displacement of 217½ tons, and drew five and one-half feet of water. Each run was made over a distance of 2,145 feet, or 0.4062 mile.

Referring to the electrical measurement data it will be observed that the electro-motive force fluctuated to a large extent, this being due to the fact that the current was taken from a street railway circuit, where the load is constantly varying. Of course this fluctuation tended to reduce the efficiency of the apparatus used in the experiment. If the traction system for the canal were supplied from power stations of its own, the pressure on the line would, from the very fact that in canal navigation such rapid changes of load would not occur as on an electrical street railway, remain comparatively steady and consequently the pull exerted by the motors on the towlines would be constant. The motor had been designed for a 500 volt current, while the voltage actually available nearly always varied much below this value; this drawback was somewhat augmented by the fact that the reducing gear of the motor had been designed for conditions somewhat different from the actual conditions under which the experiment was made and which could not readily have been predetermined. As a result the current consumed and the power developed by the motor averaged only about one-third of its rated capacity.

Electric towage being a new field for the application of electricity, experience is necessarily to be first secured by experiments such as the one under consideration. Taking the actual results, however, as they are, they go a long way towards demonstrating the fact that electric towage is feasible, practicable and full of promise in point of economy.

The vessel used in the experiment was a State repair scow, which, for a given displacement, offers more resistance than an ordinary canal boat. Yet an average speed of about two and one-half miles per hour was attained at the expenditure of only about eight and one-half electrical horse power, for the 217½ tons towed. Taking these figures as a basis, together with the price at which the Erie Canal Traction Company is bound by virtue of its franchise to furnish electric power to boatmen, namely, not to exceed twenty dollars per horse power per season of navigation, which ordinarily covers 210 days, and assuming that the tow-motor worked constantly during the whole season, thus making thirty-five single trips between Buffalo and Troy with such vessels, and at such speed as referred to above, the cost per trip would be ($8.6 \times 20 \div 35 =$) less than five dollars. This, of course, does not allow for the delays in locks and elsewhere, during which the motor could not be used to effect. But allowing for such delays, on the assumption that the traction company is not to make any rebate for time during which power is not consumed; further, taking into consideration that, if the boatman had his own tow-motor, a fair interest on the investment and an allowance for wear and tear thereon would have to be made, or, if the traction company rented out motors to the boatmen, that such rental would be added to the cost of power, the combined cost would certainly fall far short of the present cost of towage or propulsion. To further elucidate this point, the cost under the above-assumed condition of continuous work would be, at five dollars per trip, less than one and four-tenths cents per boat mile.

Now, assuming that during one-third of the entire time the motor remained idle at locks and elsewhere, although power was charged for just the same, then the cost per boat mile covered would average two and one-tenth cents, or seven dollars and sixty-six cents per trip. If, in addition to this a rental were charged for the motor, at the same rate per horse power and season, as for the electric power itself, for the entire time, including the periods of idleness, the total cost per boat mile run would amount to four and two-tenths cents, or fifteen dollars and thirty-two cents per trip. At this rate not only would power be cheap to the consumer, but the renting out of motors, I think, a profitable enterprise.

The foregoing estimate, it is to be remembered, is based upon experimental results which, as pointed out, can be improved upon and a higher degree of efficiency attained; and as the tests were made with a single scow it is obvious that with a train of canal boats the power consumed per ton mile would be less, so that the above estimate may be considered a conservative one. On the other hand, the speed factor, of course, is an important one in the calculation of the power. The energy consumed would vary, approximately, as the cube of the speed divided by the ratio of speed, whereas the item for motor depreciation or rental would vary as the power divided by that ratio. Thus, basing the calculation upon the above data, if the boat speed were to be, say, three and one-half instead of two and one-half miles per hour, the power would be increased from eight and one-half to about twenty-three and four-tenths electrical horse-power, the cost of the electric current from two and one-tenth cents to four and one-tenth cents per mile, and the item of motor depreciation or rental also from two and one-tenth to four and one-tenth cents; this would make, together, eight and two-tenths cents per mile, or twenty-nine dollars and ninety-three cents per trip, for the higher speed. A tow-motor running continuously would make forty-eight trips at the higher speed, against thirty-five trips at the lower speed per season; but if one-third the entire time were lost by delays, in either case, there would still be made thirty-two trips at the higher, or twenty-three trips at the lower speed, per season. Of course the time allowance for delays, which is here assumed at one-third of the entire season, is an arbitrary one and it seems rather unlikely that anywhere near as much time would necessarily be lost, especially with the proposed improvements in the locks. There is no occasion for the tow-motors lying idle while boats are loading or unloading, as is the case with horses or mules, for they may go on towing other boats after reaching destination, and therefore the total idleness per season would not amount to as much with a tow-motor as with horses, mules, or propellers. In view of this the above calculation is believed to leave a good margin for still further economy. In fact, the results obtained from the experiment are so encouraging as to admit of a rather unusual liberality in making allowances and deducing estimates therefrom, without even taking into calculation any improvement in the efficiency of the system over that of the experimental equipment, and this fact has induced me to go beyond precedent in regard to estimates on canal traction and include not only the cost of electrical energy, but also interest and depreciation on or rental for tow-motors, at what I deem an exceedingly liberal if not excessive figure.

Of the various systems that have been proposed or suggested for canal traction, the towage system seems to appeal most favorably to boatmen, as only the towing facilities require to be changed from the mule or horse to the tow-motor. The boatmen would be relieved not only of the uncertainty of the life and health of their animals, but the men necessary to attend the animals (usually one man per team) could be dispensed with entirely, while the space now reserved for the animals on board would be available for other purposes.

Having, in accordance with instructions of the Superintendent of Public Works, made an investigation of and submitted a report on an electric trolley system, as applied to canal traction, towards the close of the year 1893, it seems proper here to draw a comparison between the general features of the electric trolley system of propulsion and the electric system of towage. The former includes a trolley line erected along or over the canal, supplying current to the motors. In this system either special propeller boats fitted with electrical machinery are to be built, or existing boats adapted to the purpose. The towing system, on the other hand, comprises a sort of cableway or railway erected along the canal bank, and tow-motors traveling thereon; this system eliminates the necessity of building propeller boats or of reconstructing old boats for the purpose, as no machinery would be required in the hold of the boat and no space therein be encroached upon. Another feature of some value is the absence of the wash unavoidable with propellers. The towage system, further, appears to afford greater flexibility of manipulation as extra tow-motors could more readily and at less expense be kept in reserve at suitable points along the canal, to meet odd demands, than would be the case with propeller boats, and boats could be towed even singly or in couples with a fair degree of economy, not necessitating the making up of long trains as with propellers. In fact, as pointed out above, the estimates herein submitted are based upon the most uneconomical use of the power, namely, for single boats.

For trains of boats motors of suitable size and capacity could be built, or two or more motors coupled together to meet any demand.

Summing up, the electric towing system appears to present so many meritorious features that I have no hesitation in indorsing it as the system deserving preference over any other hitherto experimented upon.

The experiment, while necessarily of a somewhat crude nature, has been given thorough attention and I am indebted to Messrs. Frederick Reckenzaun, Charles N. Pratt, Alfred Green and Charles F. Burns for their valuable assistance in making the tests and in preparing the data obtained therefrom.

Respectfully submitted,

CHARLES R. BARNES.

TEST 1.

RUNNING AGAINST WIND AND CURRENT.

NOTE.—In all tests, observations were made at intervals of fifteen seconds.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	23.	350	10.79
2.	17.5	420	9.85
3.	20.	400	10.72
4.	25.	351	11.76
5.	13.	425	7.40
6.	21.	410	11.54
7.	10.	500	6.70
8.	25.	350	11.72
9.	7.	410	3.84
10.	12.	420	6.75
11.	22.	330	9.73
12.	8.	450	4.82
13.	23.	300	9.24
14.	11.5	300	4.46
15.	19.5	400	9.67
16.	29.	370	14.38
17.	19.5	375	9.80
18.	19.5	375	9.80
19.	13.5	410	7.40
20.	15.5	355	7.37
21.	17.	335	7.36
22.	16.	395	8.47
23.	11.	325	4.79
24.	15.5	375	7.64
25.	23.	500	15.41
26.	22.	400	11.79
27.	20.	450	12.00
28.	10.	450	6.03
29.	20.05	390	10.71
30.	26.	350	12.20
31.	20.	375	10.05
32.	20.	380	10.18
33.	20.	400	10.72
34.	21.	390	10.71
35.	19.	410	10.44
36.	22.	400	11.79
37.	18.5	410	10.16
38.	20.	405	10.85
39.	18.	355	8.56
40.	17.5	375	8.80

TEST 1.—*Continued.*

OBSERVATION.	Amperes	Volts.	E. H. P.
41.	17.	420	9.57
42.	18.	410	9.89
43.	19.	415	10.56
44.	14.5	385	7.48
45.	19.5	395	10.32
46.	18.	400	9.65
47.	19.	425	10.82

Total number of observations, 47. Duration of run, 11¾ minutes.

Average of observations, 18.2 amperes, 391.9 volts, 9.5 electric horse power.

Average speed, 2.07 miles per hour.

TEST 2.

RUNNING AGAINST WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	30.	425	17.09
2.	20.	400	10.72
3.	25.	355	10.55
4.	28.	350	13.13
5.	22.5	420	12.66
6.	21.5	360	10.37
7.	19.	405	10.18
8.	20.	395	10.58
9.	18.	420	10.13
10.	18.5	415	10.29
11.	16.	430	10.22
12.	17.5	420	9.85
13.	18.	415	10.

TEST 2.—*Continued.*

OBSERVATION.	Amperes	Volts.	E. H. P.
14	17.	415	9.45
15	17.5	415	9.73
16	16.5	405	8.93
17	19.	410	10.44
18	18.	415	10.01
19	19.	415	10.56
20	19.	410	10.44
21	19.	395	10.06
22	20.	405	10.85
23	21.	400	11.26
24	20.	400	10.72
25	21.	375	10.58
26	20.	395	10.58
27	21.5	400	11.52
28	20.	390	10.45
29	21.	380	10.69
30	21.	395	11.1
31	20.	380	10.18
32	21.5	380	10.95
33	19.	420	10.67
34	21.5	405	11.67
35	20.5	375	10.3
36	21.5	415	11.96
37	22.	385	11.35
38	23.	420	12.94
39	23.	395	12.24
40	23.	385	11.87
41	21.	400	11.26
42	20.	375	10.18
43	18.5	405	10.04
44	17.5	385	9.03
45	19.	420	10.67
46	20.	425	11.39

Total number of observations, 46. Duration of run, 11½ minutes. Average of observations, 20.3 amperes, 400 volts, 10.8 elec. H. P. Average speed, 2.12 miles per hour.

TEST 3.

RUNNING AGAINST WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	22.5	355	10.7
2.	23.	380	11.71
3.	20.	390	10.45
4.	21.	400	11.26
5.	19.	400	10.18
6.	19.	415	10.56
7.	17.5	410	9.61
8.	19.	405	10.18
9.	17.	405	9.22
10.	17.	420	9.57
11.	17.	405	9.22
12.	15.	405	8.14
13.	17.	410	9.34
14.	18.	420	10.13
15.	16.5	415	9.17
16.	17.5	410	9.61
17.	17.5	405	9.5
18.	18.	405	9.77
19.	16.	410	8.79
20.	17.	400	9.11
21.	15.	490	9.85
22.	17.	405	9.22
23.	17.	395	7.66
24.	16.5	405	8.93
25.	18.	415	10.
26.	16.	425	9.11
27.	16.5	400	8.84
28.	17.	420	9.57
29.	17.5	420	9.85
30.	16.5	425	9.4
31.	17.5	410	9.61
32.	18.	485	11.7
33.	18.	395	9.53
34.	15.	420	8.44
35.	16.	...	.....
36.	19.	460	11.71
37.	21.	385	10.83
38.	10.	350	4.69
39.	15.5	345	7.16

TEST 3.—*Continued.*

OBSERVATION.	Amperes	Volts.	E. H. P.
40.	18.	345	8.32
41.	19.	385	9.8
42.	16.5	450	9.95

Total number of observations, 42. Duration of run, 10½ minutes. Average of observation, 17.5 amperes, 397.5 volts, 9.3 E. H. P. Average speed, 2.32 miles per hour.

TEST 4.

RUNNING AGAINST WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	24.	370	11.9
2.	22.	385	11.35
3.	20.5	395	9.51
4.	19.5	415	10.84
5.	19.5	420	10.97
6.	....	...	.....
7.	11.	445	6.56
8.	8.	455	4.89
9.	10.	450	5.96
10.	15.	445	8.94
11.	21.	400	11.26
12.	22.	415	12.23
13.	20.	410	10.99
14.	19.	410	10.44
15.	18.	415	10.
16.	17.5	405	9.5
17.	17.5	405	9.5
18.	18.	410	9.89
19.	17.5	415	9.73
20.	17.5	410	9.61
21.	18.	415	10.
22.	18.	410	9.89

TEST 4.—*Continued.*

OBSERVATION.	Amperes	Volts.	E. H. P.
23.	18.5	405	10.04
24.	18.	410	9.89
25.	18.	410	9.89
26.	17.	410	9.34
27.	17.	410	9.34
28.	17.	410	9.34
29.	17.5	415	9.73
30.	18.	420	10.13
31.	17.	415	9.45
32.	18.	410	9.89
33.	17.5	415	9.73
34.	18.	405	9.77
35.	17.5	415	9.73
36.	18.	410	9.89
37.	18.5	410	10.16
38.	17.	400	9.11
39.	17.5	400	9.38
40.	18.	425	10.25
41.	16.	405	8.68
42.	17.5	415	9.73

Total number of observations, 42. Duration of run, 10½ minutes. Average of observations, 17.2 amperes, 402.7 volts, 9.2 E. H. P. Average speed, 2.32 miles per hour.

TEST 5.

RUNNING AGAINST WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	26.	315	10.98
2.	20.5	345	9.48
3.	20.	325	8.71
4.	21.	375	10.55
5.	21.	410	11.54

TEST 5.—*Continued.*

OBSERVATION.	Amperes	Volts.	E. H. P.
6.	15.	355	7.13
7.	13.	325	5.66
8.	13.	350	6.10
9.	14.5	345	6.6
10.	17.5	375	8.79
11.	19.	400	10.19
12.	18.	405	9.77
13.	12.5	380	6.37
14.	13.	335	5.84
15.	13.5	325	5.88
16.	15.	340	6.83
17.	15.5	330	6.86
18.	18.	380	9.17
19.	18.5	385	9.54
20.	16.5	350	7.74
21.	13.	310	5.4
22.	15.5	330	6.86
23.	17.	340	7.74
24.	20.	400	10.72
25.	19.	400	10.19
26.	18.5	410	10.17
27.	18.	420	10.18
28.	16.5	415	9.18
29.	17.	415	9.46
30.	15.	385	7.74
31.	11.5	310	4.78
32.	13.	350	6.1
33.	17.5	385	8.9
34.	20.	410	10.99
35.	19.	410	10.44
36.	18.	410	9.89
37.	19.5	410	10.71
38.	18.5	420	10.41
39.	17.5	405	9.5
40.	17.5	405	9.5
41.	17.	410	9.34
42.	15.	410	8.24
43.	17.	415	9.45

Total number of observations, 43. Duration of run, 10¾ minutes. Average of observation, 17 amperes, 374.8 volts, 8.5 E. H. P. Average speed, 2.26 miles per hour.

TEST 6.

RUNNING AGAINST WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	25.	385	12.9
2.	21.5	375	10.8
3.	20.	400	10.72
4.	18.	400	9.65
5.	19.	420	10.69
6.	17.5	420	9.85
7.	15.	390	7.84
8.	16.5	420	9.28
9.	16.5	420	9.28
10.	16.5	425	9.4
11.	15.5	415	8.62
12.	15.	410	8.24
13.	17.	415	9.45
14.	16.	400	8.57
15.	16.	410	8.78
16.	14.	415	7.78
17.	16.	405	8.68
18.	19.	425	10.82
19.	17.5	425	9.95
20.	17.5	410	9.61
21.	16.	410	8.78
22.	17.5	420	9.85
23.	17.	430	9.79
24.	17.	420	9.57
25.	16.	425	8.68
26.	16.	405	8.68
27.	17.	415	9.45
28.	17.5	425	9.97
29.	16.5	410	9.06
30.	16.5	410	9.06
31.	17.	420	9.57
32.	16.5	410	9.06
33.	17.5	400	9.38
34.	18.	430	10.37
35.	17.	415	9.45
36.	17.	405	9.57
37.	16.	420	9.
38.	15.	435	8.74
39.	15.	425	8.54

Total number of observations, 39. Duration of runs, 9¾ minutes. Average of observation, 17.05 amperes, 413.2 volts, 9.4 E. H. P. Average speed, 2.5 miles per hour.

TEST 7.

RUNNING WITH WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	9.	415	5.
2.	12.	425	6.7
3.	15.	430	8.64
4.	18.	410	9.89
5.	15.5	420	8.72
6.	15.	430	8.64
7.	13.	425	7.4
8.	13.5	440	7.96
9.	13.	450	7.94
10.	13.	445	7.75
11.	12.5	455	7.62
12.	12.5	455	7.62
13.	12.	435	6.99
14.	11.5	435	6.7
15.	11.5	435	6.7
16.	12.	435	6.99
17.	11.5	440	6.78
18.	10.	450	6.03
19.	12.5	450	7.54
20.	12.	435	6.99
21.	12.	430	6.91
22.	12.	440	7.07
23.	10.	435	5.83
24.	12.	435	6.99
25.	9.	415	5.
26.	10.	450	6.03
27.	12.	436	6.99
28.	12.	440	7.07
29.	12.5	455	7.62
30.	10.	450	6.03
31.	11.5	435	6.7
32.	12.	435	6.99
33.	12.	435	6.99
34.	11.5	435	6.7
35.	13.	450	7.94

Total number of observations, 35. Duration of run, 8¾ minutes. Average of observations, 12.18 amperes, 436.8 volts, 7.1 E. H. P. Average speed, 2.78 miles per hour.

TEST 8.

RUNNING WITH WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	18.	400	9.65
2.	12.5	455	7.62
3.	23.	410	12.64
4.	19.5	415	10.85
5.	15.	430	8.64
6.	18.	420	10.13
7.	13.	425	7.4
8.	14.	425	7.96
9.	13.	450	7.94
10.	12.5	430	7.2
11.	12.5	440	7.35
12.	12.5	445	7.45
13.	12.	440	7.07
14.	12.5	435	7.28
15.	12.	440	7.07
16.	13.	450	7.94
17.	12.5	440	7.35
18.	12.	440	7.07
19.	10.	420	5.63
20.	12.5	435	7.28
21.	13.	435	7.58
22.	13.	425	7.4
23.	12.5	445	7.45
24.	12.	410	6.59
25.	12.	445	7.15
26.	12.5	440	7.35
27.	11.5	410	6.32
28.	11.	415	6.11
29.	12.5	430	7.2
30.	12.	410	6.59
31.	12.	440	7.07
32.	12.	440	7.07
33.	11.	450	6.63
34.	12.5	435	7.28

Total number of observations, 34. Duration of run, 8½ minutes. Average of observations, 13.22 amperes, 431.6 volts, 7.6 E. H. P. Average speed, 2.86 miles per hour.

TEST 9.

RUNNING WITH WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	10.	460	6.16
2.	22.5	375	11.31
3.	16.5	375	8.04
4.	17.5	435	10.20
5.	20.	380	10.19
6.	17.	445	10.14
7.	15.5	440	9.14
8.	14.	420	7.88
9.	12.5	410	6.73
10.	14.5	455	8.84
11.	13.	440	7.67
12.	12.5	425	7.1
13.	13.5	440	7.96
14.	13.	440	7.66
15.	12.	440	7.08
16.	12.	440	7.08
17.	12.	430	6.21
18.	13.	435	7.58
19.	13.	450	7.84
20.	12.	440	7.08
21.	12.	455	7.31
22.	13.	455	7.92
23.	12.5	430	7.20
24.	13.	440	7.66
25.	12.5	455	7.62
26.	11.	450	6.63
27.	11.	425	6.26
28.	11.	445	6.56
29.	12.	450	7.23
30.	13.	435	7.58
31.	13.	450	7.84
32.	12.5	430	7.20
33.	10.	425	5.69
34.	13.	440	7.67
35.	12.	450	7.23

Total number of observations, 35. Duration of run, 8¾ minutes. Average of observations, 13.3 amperes, 434.5 volts, 7.7 E. H. P. Average speed, 2.78 miles per hour.

TEST 10.

RUNNING WITH WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	10.	460	6.16
2.	13.	440	7.66
3.	20.	380	10.18
4.	22.5	375	11.31
5.	12.5	410	6.73
6.	17.5	435	10.20
7.	13.5	440	7.96
8.	14.5	455	9.94
9.	12.	430	6.91
10.	17.	445	10.14
11.	12.	455	7.31
12.	14.	420	7.88
13.	12.5	455	7.62
14.	12.5	430	7.2
15.	12.	450	7.23
16.	13.	435	7.58
17.	10.	425	5.69
18.	11.	445	6.42
19.	16.	375	8.04
20.	11.	450	6.63
21.	15.5	440	9.14
22.	13.,	440	7.66
23.	13.	440	7.66
24.	13.	455	7.92
25.	12.	440	7.07
26.	12.	440	7.07
27.	13.	450	7.94
28.	13.	435	7.58
29.	12.5	430	7.2
30.	12.	440	7.07
31.	11.	425	6 26
32.	13.	440	7.66
33.	13.	450	7.94
34.	12.5	425	7.1
35.	10.	425	5.69
36.	12.5	430	7.2

Total number of observations, 36. Duration of run, 9 minutes. Average of observations, 13.2 amperes, 433.7 volts, 7.6 E. H. P. Average speed, 2.7 miles per hour.

TEST 11.

RUNNING WITH WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	11.	450	6.63
2.	12.5	455	7.62
3.	12.	440	7.07
4.	19.5	415	10.85
5.	12.5	430	7.2
6.	18.	420	10.13
7.	11.5	410	6.32
8.	14.	425	7.96
9.	12.	445	7.15
10.	12.5	430	7.2
11.	12.5	445	7.45
12.	12.5	445	7.45
13.	13.	435	7.58
14.	12.5	435	7.28
15.	10.	420	5.63
16.	13.	450	7.94
17.	12.5	440	7.35
18.	12.	440	7.07
19.	12.	440	7.07
20.	12.5	435	7.28
21.	12.	440	7.07
22.	13.	425	7.4
23.	12.5	440	7.35
24.	12.	410	6.59
25.	13.	450	7.94
26.	12.5	440	7.35
27.	13.	425	7.4
28.	12.5	435	7.28
29.	15.	430	8.64
30.	12.	440	7.07
31.	23.	410	12.64
32.	12.	410	6.59
33.	18.	400	9.65
34.	11.	415	6.11
35.	12.	440	7.07
36.	12.	410	6.59

Total number of observations, 36. Duration of run, 9 minutes. Average of observations, 13.1 amperes, 431.2 volts, 7.5 E. H. P. Average speed, 2.7 miles per hour.

TEST 12.

RUNNING WITH WIND AND CURRENT.

OBSERVATION.	Amperes	Volts.	E. H. P.
1.	11.5	440	6.78
2.	11.5	435	6.7
3.	12.5	450	7.54
4.	12.	435	6.99
5.	12.	430	6.91
6.	10.	450	6.03
7.	10.	435	5.83
8.	12.	440	7.07
9.	9.	415	5.
10.	12.	435	6.99
11.	12.	435	6.99
12.	10.	450	6.03
13.	12.5	455	7.62
14.	12.	435	6.99
15.	11.5	435	6.7
16.	12.	440	7.07
17.	12.	435	6.99
18.	12.	435	6.99
19.	13.	450	7.94
20.	10.	450	6.03
21.	11.5	435	6.07
22.	12.	425	6.7
23.	12.	435	6.99
24.	18.	410	9.89
25.	12.5	455	7.62
26.	15.	430	8.64
27.	13.	450	7.94
28.	13.5	440	7.96
29.	13.	425	7.4
30.	13.	445	7.75
31.	15.5	420	8.72
32.	12.	455	7.62
33.	15.	430	8.64
34.	11.5	435	6.7
35.	15.	430	8.64

Total number of observations, 35. Duration of run, 8¾ minutes. Average of observations, 12.3 amperes, 437.2 volts, 7.2 E. H. P. Average speed, 2.78 miles per hour.

SUMMARY OF OBSERVATIONS.

TEST No.	Duration in minutes.	Distance in miles.	Average E. H. P.	E. H. P. x minutes 60 = E. H. P. hours.	Average speed in miles per hour.
1.	11.75	0.4062	19.5	1.86	2.07
2.	11.5	0.4062	10.8	2.07	2.12
3.	10.5	0.4062	9.3	1.62	2.32
4.	10.5	0.4062	9.2	1.61	2.32
5.	10.75	0.4062	8.5	1.52	2.26
6.	9.75	0.4062	9.4	1.52	2.5
7.	8.75	0.4062	7.1	1.03	2.78
8.	8.5	0.4062	7.6	1.07	2.86
9.	8.75	0.4062	7.7	1.29	2.78
10.	9	0.4062	7.6	1.14	2.7
11.	9	0.4062	7.5	1.12	2.7
12.	8.75	0.4062	7.2	1.05	2.78
Totals.	117.5	4.8744		16.9	

Total duration of runs = 117.5 ÷ 60 = 1.96 hours.

Mean power applied = 16.9 ÷ 1.96 = 8.6 E. H. P.

Mean speed attained = 4.8744 ÷ 1.96 = 2.48 miles per hour.

Tests 1 to 6 inclusive were made against wind and current, the current velocity being about 1 mile per hour. Tests 7 to 12 inclusive were made with wind and current.

It will be seen from the foregoing matter on this subject that the "Lamb system" does not vary greatly in its essential features from the Milligan device described in my last annual report. The flexible cables which carry the motors in the Lamb device take the place of rigid rails to carry a similar motor of the Milligan device, and a great reduction in the cost of installation could thereby be effected, but not without losses in other directions. Owing to the unavoidable stretching and consequent sagging of the cables, the Lamb motor is compelled to climb a very steep grade as it approaches each pole, and the inevitable result is a loss of power and an uneven strain on the towing cable, both

being at the expense of increased speed. The Milligan system would avoid these difficulties, though at greater cost of installation; but it is questionable whether or not this objection would not be largely offset in the cost of maintenance.

The Milligan device provides a double track line enabling motors traveling in opposite directions to pass each other, while with the Lamb device but one track is used, and it would, therefore, be necessary either to exchange motors when they meet, or erect another line of poles and wires on the opposite bank, but in either case, with either device, frequent switches and side tracks would be found necessary in actual practice to enable motors bound in the same direction to pass each other, identically the same as in railroad practice. These problems of design and cost are certainly serious, and they must be satisfactorily solved before electric towing can be made either feasible or profitable. It must not be understood that because a motor has actually performed certain work in this line over a short piece of canal that the problem has been solved; far from it. All the devices and plans heretofore tried or examined have been extremely crude, while many absolutely ludicrous ideas have been suggested and urged upon our attention through a misconception of the conditions to be met.

About a year ago Mr. Chauncey N. Dutton, a mechanical and electrical engineer of experience and reputation, brought to my attention a device he had planned for accomplishing the electrical propulsion of canal boats. Like all the others, this device has its poor features, but it seemed to present so many points of superiority that I urged Mr. Dutton to permit of its description in these pages, and he has kindly furnished the following description and drawings, which I take pleasure in incorporating herein. The comparatively low cost of constructing the poles and trolley wire on this design; the ease with which boats could pass without the necessity of either switches or double track; the ease with which "wide waters" can be crossed with the wire, which has simply to carry its own weight, and the ease and cheapness of manipulation appeal strongly to my judgment that this device is superior to any yet tested. The difference in cost of building the trolley line of this over the other designs that have been discussed, would pay for installing a motor and screw in every boat now navigating the canals, while as a matter of fact every fourth boat only would need a propeller. Probably many of the propellers already in use could be made serviceable in connection with this device without serious difficulty. All boats, except the steam propellers, are now dependent on other power on the rivers and harbors which form essential parts of the present canal system, and in connection with which no plan for electrical propulsion would be possible except the storage battery, which in its present stage of development is altogether too heavy, clumsy and expensive to be commercially practicable.

REMOVABLE AND VERTICALLY ADJUSTABLE ELECTRICAL PROPELLING APPARATUS FOR CANAL BOATS.

INVENTED BY CHAUNCEY N. DUTTON.

While allowing this matter to be published prior to patenting the same, I reserve all my rights thereto as inventor.

(Signed) CHAUNCEY N. DUTTON.

The application of electrical power to propel canal boats is purely an engineering problem, as all the necessary mechanical devices are fully developed and well understood, and they have merely to be organized properly to do the desired work effectively. To compete successfully in this field the apparatus used must be such that the electrically propelled boat will be as well adapted to the conditions of canal navigation as is the steamboat, the only successful application of engine power to canal towing.

The success of the steam canal boat is due in large measure to the fact that she is free. She can follow the line of least resistance and navigate so as to reduce to the lowest limits the disadvantages inherent in the contracted waterway. This condition can only be satisfied with a self-propelled boat. Bank towing is precluded because it confines the boat within a certain zone, no matter how disadvantageous such restricted movements may be.

A great deal of energy has been thrown away because of the mistaken notion that a screw is an uneconomical machine. A well designed screw while one of the simplest, is also one of the most efficient modes of applying power. For canal boats twin screws should be used, because they can be smaller in diameter and located in better water than a single screw.

In all cases which have come under my notice a part of the trip of the canal boat is made in open waters where electrical propulsion is impracticable and a fixed electrical propelling apparatus would be useless and in the way.

The canal boat usually carries cargo one way and returns light, and when fully laden just clears the lock sills, while when light she draws but a few inches. Therefore the apparatus should be quickly and readily detachable and of such design that no opening need be made through the "skin" into the hold of the boat; and should be adapted to lower into good water when the boat is light, and to draw up out of danger when she is laden.

In the present state of the art the electricity must be conveyed on a shore line, and taken aboard the boat by a trolley pole.

The horse power should be the same as in the steam boats, and the tows made up and handled in the same way.

It must be borne in mind that the cost for power will be small compared with the interest on the cost of installation. The most costly part of the installation is the conductor; and, therefore, in order to keep down the interest charge, the conductor, and the poles on which it is supported, must be of the simplest and cheapest construction which will do the work effectively, and at the same time be reasonably permanent.

The apparatus here described and illustrated follows closely the general principles above set forth. In general terms it consists in a conductor supported on posts, a propelling apparatus carried on the boat, and a trolley pole readily controlled by the steersman and long enough so that with it the conductor can be reached from any part of the navigable belt of the canal.

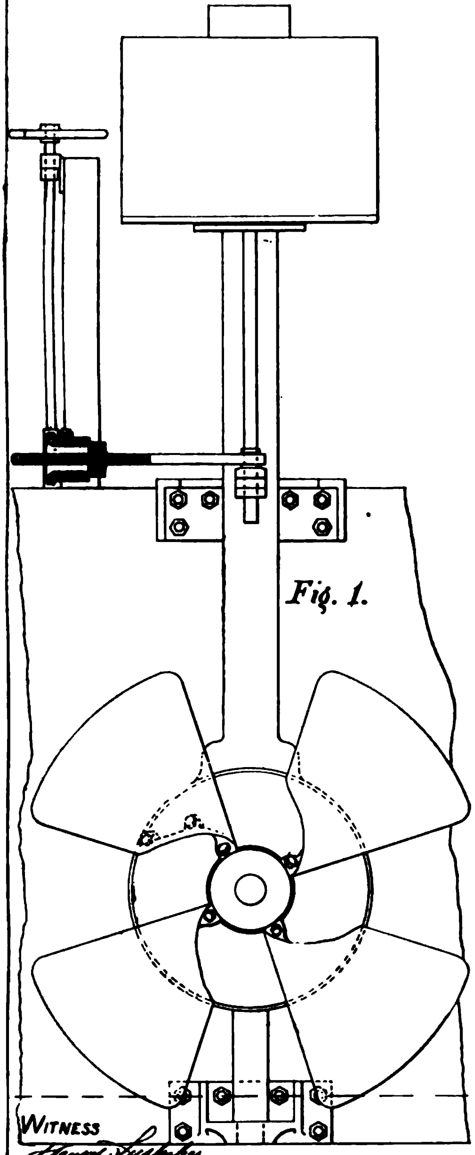


Fig. 1.

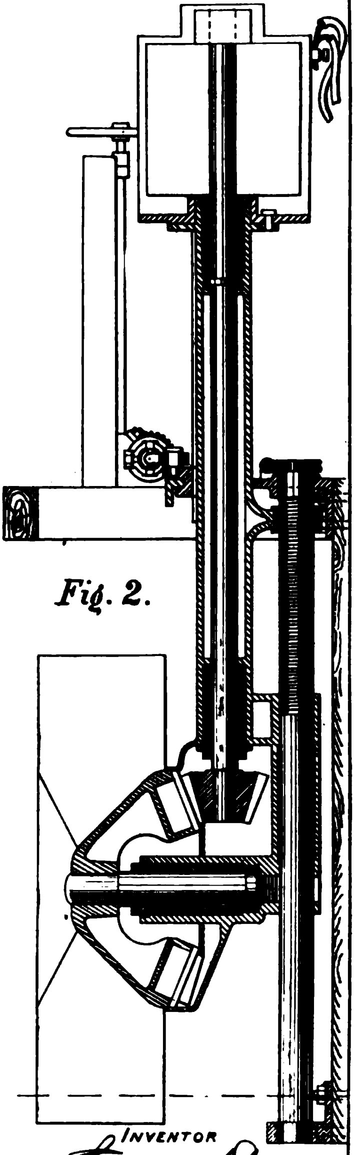


Fig. 2.

WITNESS

Henry [illegible]

Wm. A. Dutton

INVENTOR

Chauncey N. Dutton.

Fig. 3.

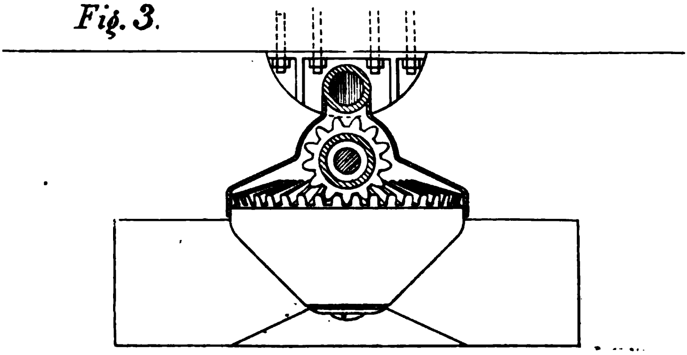


Fig. 4.

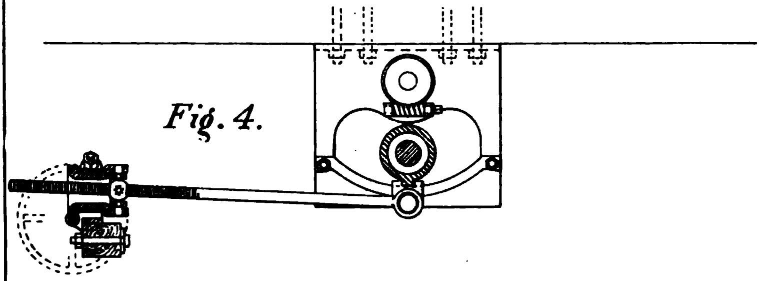


Fig. 5.

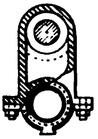
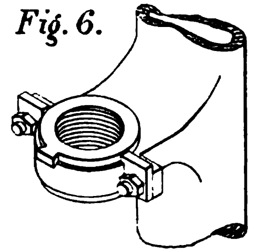


Fig. 6.



WITNESS
Henry [illegible]
Wm. A. Dutton

INVENTOR
Chauncey N. Dutton.

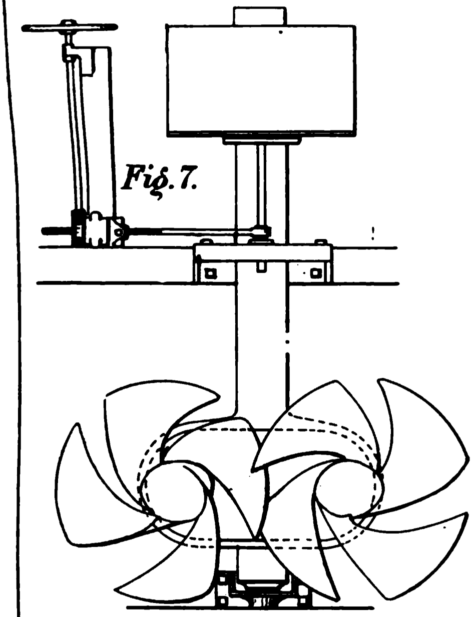


Fig. 7.

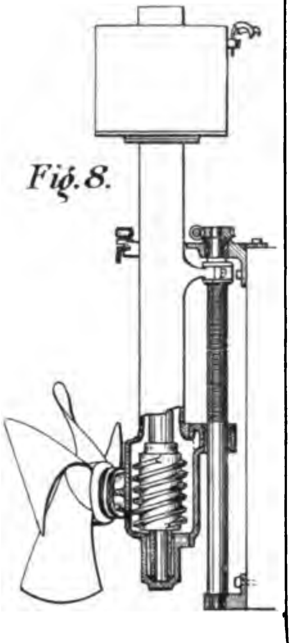


Fig. 8.

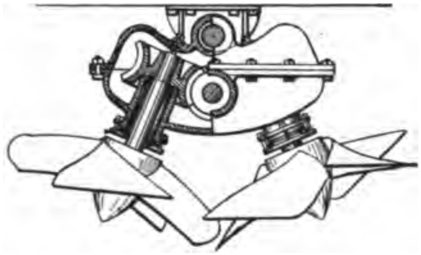


Fig. 9

WITNESSES:
Henry Lysholm
Wm. A. Dutton

INVENTOR,
Chauncey N. Dutton

Att'y.

Fig. 7.

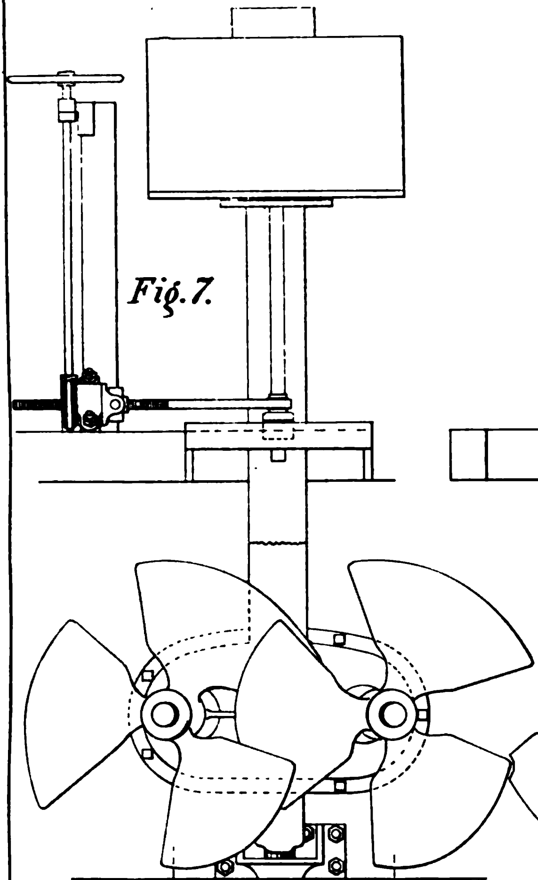


Fig. 8.

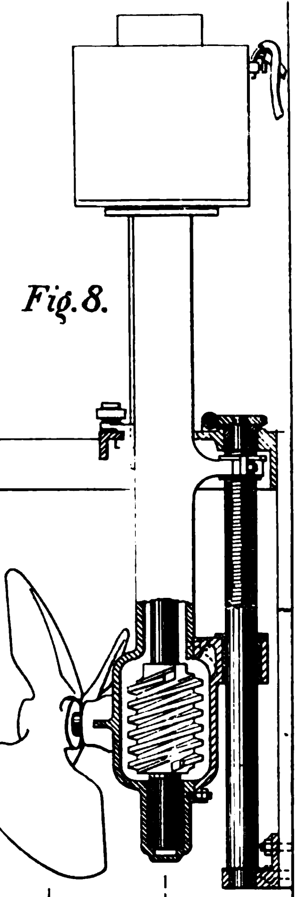
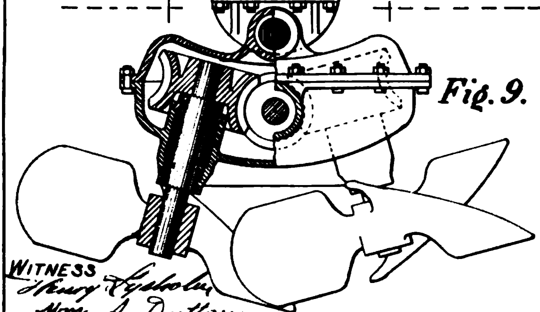


Fig. 9.



WITNESS
Henry [illegible]
Wm. A. Dutton

INVENTOR
Chauncey N. Dutton.

The posts should be about fourteen feet clear height. The conductor will be a number of soft iron or low-carbon steel wires, assembled while being strung and given just enough twist to keep them together—say a turn in ten feet. The wires are directly supported on a standing bolt which is bolted into an eye, formed in a clamp pinched onto the post. The wires are secured to the standing bolt by weaving around rivets, and subsequently riveting over them a long cap, the ends of which are lost in the strand, so as to present no obstruction to the trolley; and the clamp by which they are supported on the post is insulated from it by a cap made of heavy tough paper or felt saturated in petroleum pitch dissolved in bi-sulphide of carbon.

The trolley pole is trussed with steel wire, so as to combine the greatest possible lightness with stiffness and the necessary length. The contact may be either on a metal tube, or on a fiddle-bow arrangement of the truss wires. With such low speeds a wheeled trolley is unnecessary. The trolley pole is swiveled on a universal joint attached to a short post on deck, and its point can describe a semi-sphere. It is counterbalanced and its angle with the boat is controlled by an endless cord which passes around a winding drum convenient to the tillerman, by which he may handily adjust the position of the trolley, so that the contact will rest on the conductor.

When boats pass, one trolley will be lifted from the conductor for an instant, to allow the other to pass under.

The detachable and vertically adjustable propelling apparatus consists in a four-inch vertical steel pillar, which serves as a foundation or bed for the apparatus; a vertical cast iron tube supported and movable on the pillar, and carrying on its upper end the field magnets, and near its lower end the propellers, and their shafts and bearings, and a main shaft inside the pillar, carrying on its upper end the armature of the motor, and on its lower end the gearing by which the propellers are driven.

No rudder is contemplated. The boat will be steered by swinging the propelling apparatus on the pillar as a pivot. For this purpose a worm steering gear is provided operated by a wheel, and connected to the propelling apparatus by a block which engages a spline formed on the back side of the tube and sliding thereon when the latter is adjusted. The pillar is carried in two bearings; one, a foot bearing, formed in a step bolted on at the bottom of the sternpost, the other a collar bearing at the top thereof, which can be readily detached so that the pillar can be lifted out of the foot bearing and the entire apparatus readily removed. The lower part of the pillar is turned smooth, its upper part is threaded, and on its upper end, above the deck, is a worm gearing by which the pillar can be turned in its bearings to adjust the vertical position of the propellers.

The cast iron tube which carries the entire apparatus has two bearing blocks by which it is supported on the pillar. The lower block, which is bushed and slides on the smooth part of the pillar, is right behind the screws and transmits their thrust to the pillar and the boat.

The upper block carries a nut which engages the threaded part of the pillar. When the pillar is turned, the motive apparatus is moved up or down by the engagement of the nut and thread.

The tube has in its upper part a shouldered bearing for the main shaft, and in its lower end a steady rest for the lower end of the shaft, and an enlargement or wheel chamber gives space for the gearing which drives the propellers, and also supports the shaft bearings. The back of this chamber is a removable plate, so that the gearing is accessible.

The chamber is designed to be filled with oil so that the gearing will run in oil. The shafts are inclined horizontally with the axis of the boat for the double purpose of making a compact gearing and small wheel chamber and throwing the propellers out towards the sides of the boat in better water. The thrust of the propeller shafts is taken on adjustable steel blocks, and each shaft has a gland to confine the oil in the wheel chamber. The gearing is a multiple-thread worm on the main shaft and worm wheels on the propeller shafts, large multiple threads of sharp pitch being used to increase the wearing surfaces. The reaction of the gears is vertically against the worm, so that the weight of

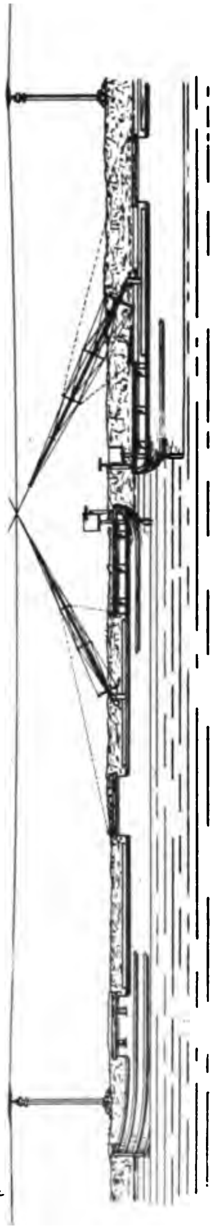


Fig. 10.

WITNESSES:

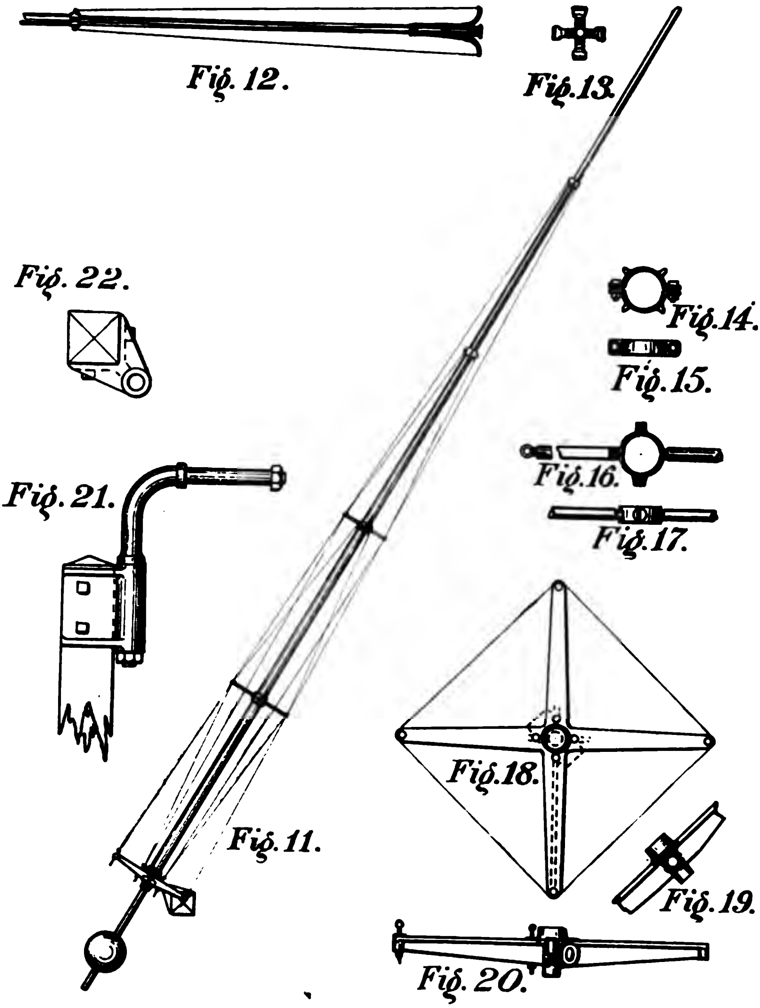
Henry Ley Scheler

Wm. A. Dutton

INVENTOR,

Chauncey N. Dutton

Att'y.



WITNESSES:
Henry Eyeholm
Wm. A. Dutton

INVENTOR,
Chauncey N. Dutton.

Att'y.

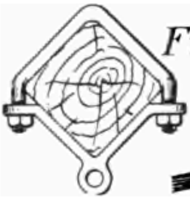


Fig. 23.

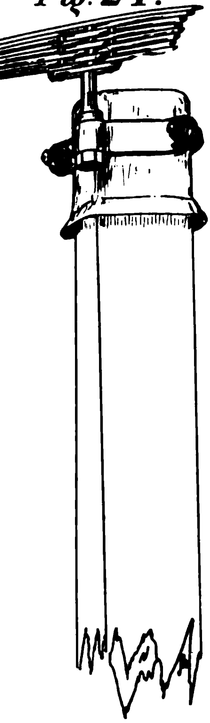


Fig. 24.

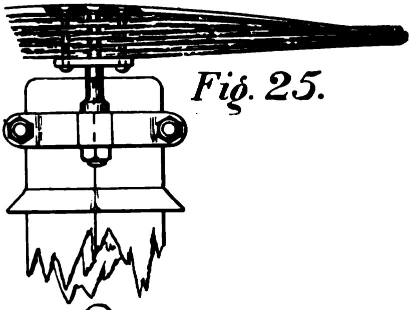


Fig. 25.

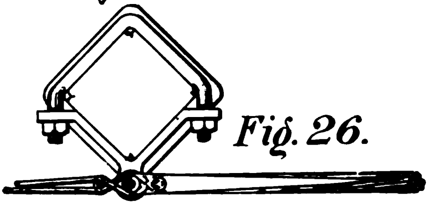


Fig. 26.

WITNESSES:
Henry Lydecker
Wm. A. Dutton

INVENTOR.
Chauncey N. Dutton.

Att'y.

the armature is supported on the teeth of the gears when developing normal power.

The propellers are intended to run at 400 revolutions per minute to make a speed of six miles an hour; and the shaft and motor at 1,600 revolutions.

The electrical motor is self-centering, the armature being keyed to the shaft, and the field magnets being bolted to a bedplate which is bolted to a flange on the cast iron tube, and centered on the turned end thereof.

No novel details being essential in the switches, rheostat, and other electrical details, they are not shown.

DESCRIPTION OF FIGURES.

Figs. 1, 2 and 3 are views of an apparatus with a single propeller driven by a bevel pinion on the motor shaft and a mortise bevel wheel on the propeller.

Fig. 4, a plan of the steering gear.

Figs. 5 and 6, details of the vertical adjustment.

Figs. 7, 8 and 9 are details of an apparatus with twin screws, and worm gearing.

Fig. 10 is a general view, showing the mode of manipulating the trolley poles.

Figs. 11 to 22 are details of the trolley pole.

Figs. 23 to 26 are details of the conductor.

BEYER'S PROPELLING APPARATUS FOR VESSELS.

Numerous devices are constantly being brought out for improving present methods connected with canal transportation, and the opinions and advice of this Department are sometimes asked thereon. A case in point is the invention of Mr. Louis Beyer, of Washington, D. C., whereby it is claimed among other things, that the present troublesome wash from the propellers can be avoided.

This is a matter of serious importance, so, in order to bring it to the attention of those interested in canal matters, Mr. Beyer was asked to provide a description and drawings of same to be used in this report, to which he has acquiesced, as will be seen from the following, which I take pleasure in presenting:

WASHINGTON, D. C., *December* 4, 1895.

Hon. CAMPBELL W. ADAMS, *State Engineer and Surveyor,*
Albany, N. Y.:

Dear Sir.—I have the honor to submit herewith, for your consideration, the description of a new and useful improvement in propelling apparatus for canals and other inland waters.

The main and great object of this invention is to prevent the washing of the banks of canals, rivers, etc., especially when transporting canal boats by steam or similar power. The canal boats can be propelled at a much greater speed than is done at present, without the waves made as at present, when using paddle-wheels, propellers or their equivalent. The water is always carried towards the center line of the boats and produces no waves, the only waves possibly made being those originating from the passage of the boat through the water at the bow. This propelling apparatus does not require the amount of power now necessary with ordinary propeller or water-wheels, as there is virtually no slip, and at each stroke of the paddles their full surface is exerted against the water. The paddles being arranged with cranks at 120 degrees each, the motion is steady and continuous, thus preventing vibrations and thumpings, as now occasioned by the means employed, such as propellers, etc. The different parts are easily and readily accessible and can be quickly replaced in case of breakage.

The apparatus has been thoroughly tested in the canal terminating at Washington, D. C., and from its efficiency and success demonstrated in this trial, I am confident that a speed of from four to six miles can be obtained without causing absolutely any wash. A much greater speed can be obtained if necessary.

A detailed description of the construction and working of this apparatus can be obtained by reference to the accompanying drawings, in which—

Figure 1 represents a perspective view of the propelling apparatus containing my improvement. Figure 2, is a plan or top view of the same. Figure 3, is a side elevation of the same. Figure 4, is a detail view of the crank and jointed yoke attached to an end of the pitman. Figure 5, is a part top view of the segment, showing the friction rollers connected to the upper end of a rudder.

In accompanying drawings, A represents part of the stern of a vessel, which can be of any size and construction, and may be either a rowboat, canal boat, steamboat or ship, or any other vessel to be driven by power of any kind. To this stern the propelling mechanism is firmly secured in any suitable manner. It consists of one, two or more paddles, B (four being shown in the drawing, although I prefer to employ six, by which greater steadiness and evenness is obtained), and each is attached to a shaft arranged in journals C. The paddles are formed of the upper round part b, and the lower flat part b′, and this is made with one side of the flat part wider than the other side from the center line of the rudder, especially when two or more paddles are employed, so that they can readily pass each other when in motion. By this means the centers of the parts b can be brought closer together, and the turning of the paddles for feathering them is also facilitated. The paddles, especially for large vessels, are to be made of wrought iron, steel, or other suitable material for strength and elasticity. The upper part b of these paddles extends between the arched segments or arcs D, which are made of two segmental pieces with a space between them, for the passage of said part b, and they are firmly secured to the deck or other convenient place on the vessel, and said part b is provided with a bearing-block d, which guides the paddle at its upper end. A short distance below the top of the paddle a crank arm e, is secured, which carries at its outer end a friction roller f, bearing against the outer side of the lower part of the segment to prevent friction. To the block d, a pitman E, is attached, which in turn is connected to the upper end of a lever F, pivoted with its lower end to a fulcrum G, secured in any suitable manner to the vessel. About centrally of the pivoted lower F, another pitman H, is connected in any suitable manner at one end, while its opposite end is attached to the crank pin of a shaft I, mounted in suitable bearings. If desired, the piston rod of the engine may be directly connected to said lever F, or other equivalent driving mechanism may be employed to impart motion to the lever in a direct manner.

The reversing mechanism consists of a pivoted lever K, to one end of which a forked rod L, is attached while its opposite end is secured to the pendent part of D′ of the segment, which also assists in supporting the outer end of the paddle shaft. The inner end of the lever K, is connected to a pitman M, which is attached to a jointed yoke M′, in which operates a cam or crank m secured to the crank shaft N, operating in journals n. The crank m imparts motion to the lever K in either direction, and thus the action of the paddles can be reversed. On the crank shaft N, a bevel wheel O, is secured, meshing with another wheel P, on shaft O, which is operated in any suitable manner, and thus imparts motion to the crank shaft. Any equivalent mechanism may be substituted for that herein shown.

As a modification of the crank e, on the paddle, with its friction roller f, a crank or arm e′, provided with a friction roller f′, may be employed. It is secured to the extreme upper end b, of the paddles, and extends on one side of the segment, as plainly seen in figure 5.

The paddles when arranged in pairs may be so placed that they will work together, or one of the inside pair of paddles and one of the outside pair of paddles, or they may be operated singly, i. e., one at a time, and operated so the vessel can be turned on its center.

If at any time it is desired, the paddles may be set deeper into the water, to prevent racing of the engine, and also to give a greater surface-bearing against the water. If from any cause one of the

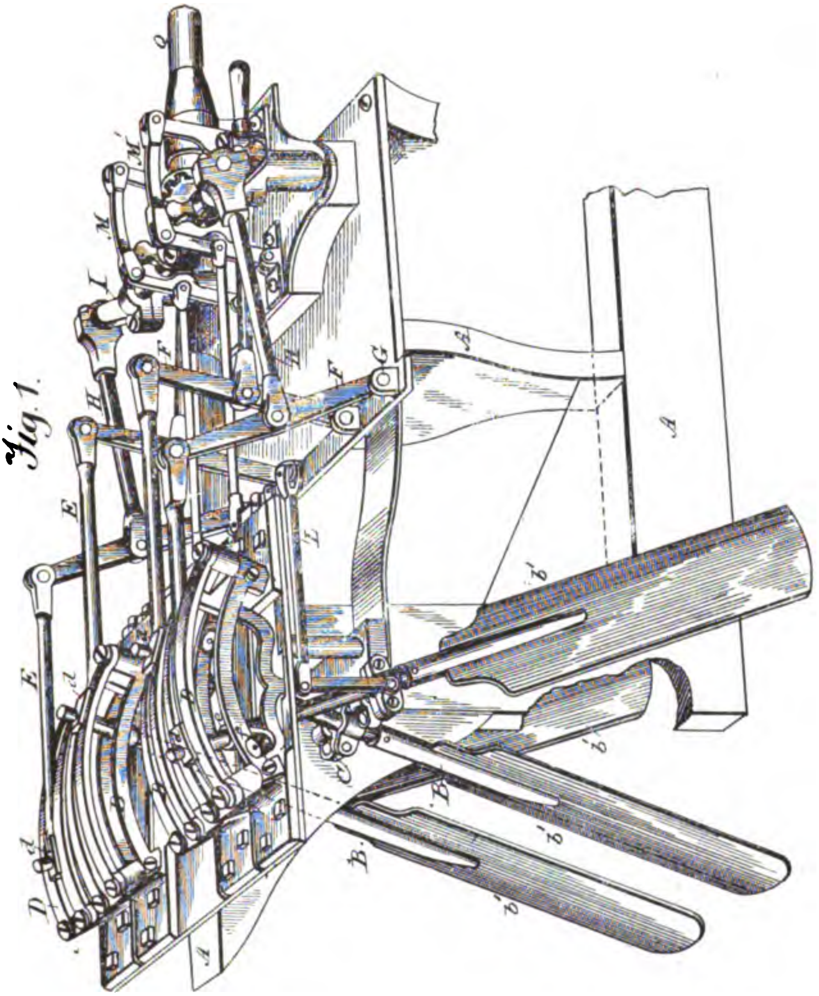
(No Model.) 3 Sheets—Sheet 1.

L. BEYER.

PROPELLING APPARATUS FOR VESSELS.

No. 505,785. Patented Sept. 26, 1893.

Fig. 1.



Witnesses.

A. Ruppert.

Wilhelm Ruppert.

Inventor:

Louis Beyer,

By T. C. Brecht,

Attorney.

(No Model.) 3 Sheets—Sheet 2.

L. BEYER.

PROPELLING APPARATUS FOR VESSELS.

No. 505,785. Patented Sept. 26, 1893.

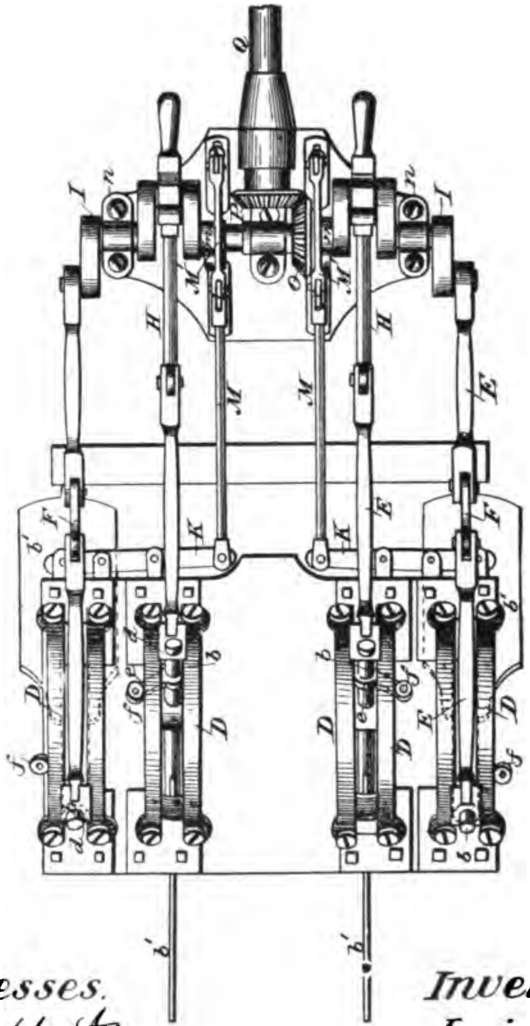


Fig. 2.

Witnesses.
A. Ruppert.
Mathew Ruppert

Inventor:
Louis Beyer,
By J. C. Brecht
Attorney.

In Memoriam.

On April 11, 1895, JOHN BISGOOD, Division Engineer of the Western Division, was suddenly removed from our ranks by the grim messenger of death. He had reached the ripe age of seventy-two years, nearly forty of which were spent in almost uninterrupted service on the State canals. Mr. BISGOOD was born in Ireland, came to this country at an early age and settled in Rochester. His training as an engineer began at Maynooth College, Dublin.

He was Resident Engineer of the Western Division for twelve years, and for five years prior to his death he was Division Engineer of the same division. Many of the more important works and structures on that section of the canal attest his skill and judgment as an engineer and remain as fitting monuments to a life well spent.

JOHN BISGOOD.

APPENDIX.

APPENDIX A.

ENGINEERING EXPENSES FOR THE FISCAL YEAR.

ORDINARY REPAIR FUND.

DIVISION.	CANALS.				
	Erie.	Champlain.	Oswego.	Black River.	Cayuga and Seneca.
Eastern	$8,968 98	$4,323 36	....	....	....
Middle	5,449 99	....	$640 84	$1,449 83	$494 32
Western	8,635 49	....	....	....	....
Total	$23,054 46	$4,323 36	$640 84	$1,449 83	$494 32

Total $29,962 81

SPECIAL APPROPRIATIONS.

Examination, monuments and maps disbursed by division engineers, chapter 358, Laws of 1894, and chapter 932, Laws of 1895	$1,775 32
Examination, monuments and maps paid directly by State treasurer, chapter 358, Laws of 1894, and chapter 932, Laws of 1895	5,543 98
Upper Hudson river survey, chapter 599, Laws of 1895	8,000 00
	$15,319 30

EXTRAORDINARY CANAL IMPROVEMENTS.

Eastern Division.

Deepening Erie canal, chapter 119, Laws of 1893, and chapter 572, Laws of 1894	$1,327 50
Repairing Cohoes dam, chapter 643, Laws of 1893, and chapter 462, Laws of 1894	565 38

Improving Saranac river, chapter 169, Laws of 1894	$152 77
Repairs to Glens Falls feeder, chapter 278, Laws of 1894	1,144 43
Shinnecock and Peconic canal, chapters 358 and 768, Laws of 1894, and chapter 932, Laws of 1895	835 07
Improving Champlain canal, chapter 572, Laws of 1894	3,959 26
Lengthening Lock No. 20, Erie canal, chapter 572, Laws of 1894	3,042 09
Repairs to Lock No. 1, Erie canal, chapter 572, Laws of 1894	715 65
Bridges Nos. 39 and 40, Champlain canal, chapter 572, Laws of 1894	159 77
Lansing's waste weir, chapter 572, Laws of 1894	919 80
Canajoharie bridge, chapter 592, Laws of 1894	48 00
Ensign brook, Champlain canal, chapter 593, Laws of 1894	110 55
North street bridge, Mechanicville, chapter 594, Laws of 1894	672 70
Rocky Rift feeder, chapter 655, Laws of 1894	238 41
Fort Herkimer waste weir, chapter 67, Laws of 1895	447 64
Wall at Schuylerville, chapter 105, Laws of 1895	403 13
Manor avenue bridge, Cohoes, chapter 139, Laws of 1895	348 96
High street bridge, Cohoes, chapter 141, Laws of 1895	350 39
Basin street bridge, Sandy Hill, chapter 143, Laws of 1895	301 00
Cemetery culvert, Waterford, chapter 176, Laws of 1895	87 55
Repairs to Glens Falls feeder, chapter 284, Laws of 1895	102 15
Wall at Glens Falls feeder, chapter 286, Laws of 1895	555 58

Schenectady wall, chapter 288, Laws of 1895....	$100 60
Tow path, Smith's Basin, Champlain canal, chapter 298, Laws of 1895......................	1,173 33
Lengthening Locks 21 and 22, Erie canal, chapter 320, Laws of 1895..........................	832 14
Repairs to Rexford Flats dam, chapter 560, Laws of 1895	597 11
Sea wall at Orient, chapter 838, Laws of 1895....	1,025 51
Dredging Albany basin, chapter 963, Laws of 1895	947 70
Dredging West Troy basin, chapter 966, Laws of 1895	254 90
Drake's drawbridge, chapter 1009, Laws of 1895	79 43
	$21,498 50

SPECIAL SURVEYS.

Making surveys and maps for use of the State Board of Claims......	$4,482 95	
Making surveys and maps required by State Engineer, chapter 358, Laws of 1895.................	1,297 41	
Upper Hudson river survey, chapter 599, Laws of 1895..........	3,920 41	
		9,700 77
		$44,491 61

Middle Division.

Completion of highway head of Owagena lake..	$182 27
Constructing drain at Whitesboro.......... ...	42 43
Cleaning Madison brook feeder................	1,622 11
Lift bridge at Geddes street, Syracuse..........	1,949 18
Gilbert street wall at Utica..................	1,216 03
Genesee street bridge at Utica................	2,485 59
Improving Cowaselon creek.................	1,184 41
Repairs to Owasco lake outlet............. ...	230 54

Vertical wall at Higginsville	$22 14
Lift bridge at Genesee street, Syracuse	245 54
Vertical wall at Clay street, Utica	63 78
Otisco lake inlet bridge	232 37
Road bridge over Butternut creek	7 48
Cleaning lake brook ditch	59 40
Cleaning Manlius ditch	179 55
Gilbert street wall at Utica	4 50
Improving channel, Butternut creek	3 50
Cleaning ditch, town of Elbridge	9 76
Canasaraga creek culvert	43 76
Stone dam at Baldwinsville	2,425 17
Cleaning State ditch at Liverpool	93 83
Improving Oswego canal	131 09
Road bridge at Liverpool	100 00
Stone apron to Oswego dam	1,303 21
Steel apron to Braddock's dam	60 30
Rebuilding locks, Black river canal	2,789 78
Surveys on account of Attorney-General	1,477 44
Sluice in spillway at North Branch Reservoir	1,107 97
River bridge at Carthage	142 23
Repairs to North Branch Reservoir	795 13
Swing bridge at Garden street, Rome	13 54
Rebuilding locks, Black river canal	56 79
Protecting Cayuga and Seneca canal at Geneva	1,408 65
Dredging Cayuga lake inlet at Ithaca	289 85
Improving Cayuga and Seneca canal at Seneca Falls	1,405 29
Dredging State ditch between Seneca Falls and Waterloo	182 47
Repairs to highway at Cayuga	141 39
Protecting Cayuga and Seneca canal at Geneva	285 84
Improving Cayuga and Seneca canal at Waterloo	176 30
Improving Cayuga and Seneca canal at Seneca Falls	14 60
Improving Cayuga and Seneca canal and Seneca lake level	252 06

Removing obstructions foot Cayuga lake.......	$298 61
Pier and breakwater at Canandaigua..........	4 00
Constructing highway, Onondaga Indian reservation	78 25
Examination monuments and maps............	170 64
Channel lake, Ontario, to Wigwam cove........	260 93
Piling outlet, Lake Keuka.....................	97 05
Bridge survey foot Cayuga lake................	412 55
Total engineering expenses for Middle Division	$25,759 30

Western Division.

Oak Orchard creek and feeder.................	$699 60
Genesee Valley canal nuisances...............	540 00
Chemung canal nuisance......................	4 90
Chemung canal nuisance......................	28 40
Emerson street lift bridge, Rochester...........	1,700 00
Dredging Ohio basin, Buffalo, N. Y.............	4,194 30
Fall creek wall, Havana, N. Y.................	401 17
Examinations and maps......................	307 27
Griffith street bridge, Rochester...............	789 00
Pile dyke at Corning.........................	100 00
Improving Seneca lake level, Chemung canal....	86 72
Adams street lift bridge, Lockport.............	325 00
Pickard's bridge	1,242 39
West Main street bridge, Rochester............	283 00
Jersey street bridge abutments, Buffalo........	645 85
Main street bridge, Fairport..................	176 78
Pendleton culvert	49 18
Mill street bridge, Buffalo....................	146 23
Ditches in Tonawanda and Amherst............	500 00
Bridge, etc., Falls creek, Montour Falls.........	94 35
Beeman's creek	79 50
Glen creek, Watkins.........................	157 86

Main street bridge, Newark	$35 45
Dyke at Corning	178 63
Erie basin and docks, Buffalo	83 33
Deepening, etc., Mud creek	500 00
Dredging lower Black Rock harbor, Buffalo	152 67
Genesee Valley canal nuisances	59 02
Bull creek	216 20
Sewer at Horseheads	615 75
Chemung river bridge abutments at Chemung	23 20
Diven's ditch and culvert	139 98
Cuba reservoir spillway	56 20
Survey for Court of Claims	193 61
Ordinary repairs	8,635 49
Total engineering expenses for Western Division	$23,440 87

SUMMARY.

Ordinary repairs	$29,962 81
Extraordinary canal improvement	62,063 18
Special appropriations	15,319 30
Total engineering expenses	$107,345 29

FINAL ACCOUNTS PASSED IN THIS OFFICE DURING THE FISCAL YEAR ENDING SEPTEMBER 30, 1895.

Number.	CHARACTER OF WORK.	NAME OF CONTRACTOR.	Engineer's estimate at contract prices.	Amount of final accounts.
1	Stone dam at Baldwinsville	Hughes Bros. & Bangs	$60,000 00	$56,041 95
2	Two lift and one fixed bridge over Erie canal at Genesee street, Utica, N. Y	Hilton Bridge Construction Co	....	48.920 74
3	Sluice in North Branch reservoir	A. C. Hall	7,992 00	6,175 69
4	Lock No. 18, Black River canal	A. Van Wagner Co	18,837 50	17,502 90
5	Lock No. 28, Black River canal	Mulchay & Co	17,770 50	17,201 59
6	Lock No. 37, Black River canal	Mulchay & Co	17 094 00	14,619 36
7	Removing obstructions foot Cayuga lake	J. J. Hallock	4,000 00	3,018 60
8	Protecting berme bank Cayuga and Seneca canal at Geneva	Brayer & Albaugh	13,853 50	12 491 89
9	Removing bars and dredging channel Cayuga inlet	Hingston & Wood	5,000 00	3,802 14
10	Repairs to Madison and Lebanon feeders	Edward S. Candee	9,924 44	8,837 79
11	Removing superstructure at Geddes street and re-erecting at Liverpool	Brummelkamp & Lane	1,465 00	1,103 87
12	Rebuilding berme abutment Main street bridge at Jordan	Edward S. Candee	3,382 00	5,957 76
13	Improving Cayuga and Seneca canal at Seneca Falls	G. W. Barlow	12,438 00	7,091 75
14	Substructure lift-bridge at Geddes street	Martin & Sullivan	6,873 00	4,906 90
15	Superstructure lift-bridge at Geddes street	Wrought Iron Bridge Co	....	7,634 62
16	Vertical wall between Gilbert and Turner streets, Utica	James J. Dwyer	9,795 00	7,958 27
17	Taking out and removing machinery for operating lift-bridges at Genesee street, Utica, and substituting air compressor	Hilton Bridge Construction Co	....	9,755 15
18	Improving Oak Orchard creek, Oak Orchard feeder	MacGregor & Hughes	29,000 00	27,223 23
19	Abatement nuisance Falls creek, Havana	A. F. Chapman	893 40	884 75
20	Abatement nuisance between Horseheads and Pine Valley	A. F. Chapman	4,428 90	5.393 62
21	Abatement nuisance between Lock 48 and Grand Central avenue, Elmira	A. F. Chapman	4,203 60	4,111 01
22	Dredging Erie basin, Buffalo	Hingston & Wood	1,998 00	2,161 14
23	Vertical wall, Falls creek, Havana	John Coughlin	1,808 00	3,639 38
24	Deepening channel Honeoye outlet	Michael Bennett	3,251 00	3.288 28
25	Improving Genesee Valley canal	Brayer & Albaugh	3,580 00	4,913 39
26	Substructure bridge over Tonawanda	Logie & Leh	2,577 00	2,505 92
27	Two spans superstructure bridge over Tonawanda	Wrought Iron Bridge Co	4,175 00	5,267 00
28	Substructure bridge Jersey street, Buffalo	B. P. Smith	4,920 00	4.972 06
29	Superstructure bridge Griffith street, Rochester	Rochester Bridge and Iron Works	4.175 00	4,189 00
30	Substructure bridge Griffith street, Rochester	B. P. Smith	1,912 00	2,519 69
31	Repairs to Rocky Rift feeder	Troy Public Works Co	7,405 50	7,407 66
32	Repairs to Lock No. 1	Cunningham & Monty Co	8,536 50	9,591 26
33	Lengthening Lock No. 20	John Twomey	34,294 65	35,030 89
34	Machinery for Lock No. 20	Wm. B. Wemple & Sons	1.200 00	1,200 00
35	Repairs to Fort Herkimer waste weir	Michael Bennett	3,564 70	4,303 02
36	Manor avenue bridge, Cohoes	Hilton Bridge Construction Co	2,833 00	3,617 94
37	Repairs to Cohoes dam	Cunningham & Monty Co	87,389 00	104,314 86

FINAL ACCOUNTS PASSED IN THIS OFFICE DURING THE FISCAL YEAR ENDING SEPTEMBER 30, 1895—(*Continued*).

Number.	CHARACTER OF WORK.	NAME OF CONTRACTOR.	Engineer's estimate at contract prices.	Amount of final accounts.
38	Superstructure bridges 39 and 40	Hilton Bridge Construction Co.	$1,450 00	$1,450 00
39	Rebuilding Lansings waste weir	Pidgeon & Co	9,542 20	10,437 95
40	Improving 5,200 lineal feet of the Champlain canal from Bemis Heights waste weir northerly	Troy Public Works Co.	35,385 25	35,891 24
41	Abutments and approaches to North street bridge, Mechanicville, N. Y	Troy Public Works Co.	3,155 20	3,603 54
42	Superstructure North street bridge, Mechanicville	Wrought Iron Bridge Co.	1,600 00	1,600 00
43	Conveying waters of the Ensign brook	John Twomey	1,021 40	965 00
44	Vertical wall at Glens Falls feeder	Flood & Sherrill	9.124 86	9,612 16
45	Basin street bridge, Sandy Hill	Reilly, Reardon & Dempsey	2.197 10	2.821 85
46	Approaches to swing-bridge over Shinnecock and Peconic canal	P. J. Brummelkamp	2,798 70	3.018 30
47	Piling and protecting banks, Shinnecock and Peconic canal	P. J. Brummelkamp	12,547 80	13,003 09
48	Mole at Houghtaling Island	William D. Fuller	985 00	980 56

TABLE OF CONTRACTS PENDING ON THE NEW YORK STATE CANALS ON THE 30TH DAY OF SEPTEMBER, 1895.

NAME OF CONTRACTOR.	Date of contracts.	CHARACTER OF WORK.	LEGISLATIVE		Appropriation.	Engineer's estimate.	Engineer's estimate at contract price.	Payments to date
			Chap.	Year.				
James B. Donnelly	Nov. 1, 1894	Stone apron to Oswego dam	572	1894	$30,000 00	$24,185 00	$23,208 00	$19 907 00
Edward S. Candee	Aug. 2, 1895	Otisco lake inlet bridge	497	1895	8,000 00	7.964 00	6,209 00	1,105 00
E. H. Fleming & Co	Aug. 6, 1885	Protecting Cayuga and Seneca canal at Geneva	142	1895	15,000 00	15,000 00	10,943 00	2.465 00
Michael Bennett	Aug. 28, 1895	Road over spillway at North Branch reservoir	148	1895	25,000 00	3.853 50	5,137 17	1.411 00
John H. Nelson	Aug. 29, 1895	Discharge pipes at North Branch reservoir	148	1895		17,983 50	16,764 50	....
E. G. Gay	Aug. 29, 1895	State ditch at Cowaselon swamp	306	1895	30,000 00	29,925 00	21,350 00	1,360 00
J. J. Hallock	Aug. 30, 1895	Repairs to Owasco lake outlet	99	1895	12,000 00	12,000 00	8,842 88	442 00
George W. Barlow	Aug 30, 1895	Improving Cayuga and Seneca canal at Waterloo	572 512	1894 1895	20,000 00	14,297 00 12,166 00	7,837 00	221 00
Willard Johnson	Aug. 31, 1895	Improving Cayuga and Seneca canal at Seneca Falls	512	1895		12,166 00	8.230 50	425 00
Dodge & MacGregor	Sept. 7, 1895	Rebuilding combined locks 39, 43 Black River canal	1030	1895	45,000 00	45,000 00	38,881 50	....
Hughes Bros	Sept. 9, 1895	Steel apron to portion Braddock's dam	572 368	1894 1895	25.000 00	16,475 00	14,756 00	1,275 00
James J. Dwyer	Sept. 17, 1895	Vertical wall at Gilbert street, Utica N. Y	968	1895	10,000 00	9,993 50	7,384 95	....
Lauer & Hagaman, Brayer & Albaugh	Sept. 20, 1895	Vertical wall at Clay street, Utica	367	1895	2,500 00	2,499 50	2,042 25	....
Lauer & Hagaman, Brayer & Albaugh	Sept. 20, 1895	Piling outlet Lake Keuka	1009	1895	8,500 00	8,414 00	6,309 00	....
Lauer & Hagaman, Brayer & Albaugh	Sept 20, 1895	Vertical wall at Higginsville	299	1895	2,500 00	2,399 00	1,849 50	....
John Hannan	Sept. 3, 1895	Opening channel at Wigwam Cove, Lake Ontario	1009	1895	10,000 00	10,000 00	8,250 00	....
E. H. Fleming & Co	Oct. 1, 1895	Improving Cayuga and Seneca canal and Seneca lake outlet	308	1895	20,000 00	13,600 00	10,041 00	442 00
Logie & Leh	Dec 26, 1894	Taking down bridge at Porter avenue, Buffalo, and erecting same at Jersey street	668	1894	10,000 00	1,000 00	946 25	....
Buffalo Dredging Company	Dec. 28, 1894	Dredging and docking in Ohio basin and slips and substructure for swing-bridge over entrance to same in Buffalo, N. Y	145	1894	60,000 00	43,297 00	36,328 00	27,013 00
Wrought Iron Bridge Company	Dec. 28, 1894	Swing-bridge over entrance to Ohio basin at Ohio street, Buffalo	145	1894		8,217 00	5,624 00	2,397 00
Wrought Iron Bridge Company	Feb. 18, 1895	Lift-bridge over Erie canal at Emerson street, Rochester	336 560	1893 1894	17,000 00	9,974 27	9,940 00	5,066 00
Chambers & Casey	May 9, 1895	Substructure for bridge over Erie canal, Main street, Fairport	576 151	1894 1895	6,500 00	6,044 00	5,198 00	....

TABLE OF CONTRACTS PENDING ON THE NEW YORK STATE CANALS—(*Continued*).

NAME OF CONTRACTOR	Date of contract.	CHARACTER OF WORK.	LEGISLATIVE.		Appropriation.	Engineer's estimate.	Engineer's estimate at contract price.	Payments to date.
			Chap.	Year.				
Hilton Bridge Construction Co.	July 27, 1895	Substructure and superstructure for bridge over Erie canal at Mill street, Buffalo	18	1895	$9,500 00	$6,440 00	$6,944 60	....
J. J. Churchyard..............	Aug. 8, 1895	Docking and dredging in Erie basin, Buffalo..	224	1895	5,378 00	4,473 40	4 321 90	....
R. E. Beardsley................	Aug. 24, 1895	Brick sewer in Horseheads from intersection of Chemung canal to New Town creek......	679	1895	10,000 00	7,420 25	6,984 50	$3,111 00
Frank J. Le Valley............	Sept. 11, 1895	Ditch and iron culvert to drain land in town of Pendleton, Niagara county...............	17	1895	2,000 00	1,819 00	1,780 00	....
Groton Bridge Company.......	April 13, 1895	High street bridge, Cohoes..................	141	1895	4,000 00	3,557 00	3,367 00	....
P. W. Myers & Son............	Aug. 26, 1895	Dredging Albany basin.......................	963	1895	15,000 00	12,600 00	9,513 00	2,482 00
Cunningham & Monty..........	Aug. 26, 1895	Repairing berme bank at Schuylerville.......	105	1895	12,000 00	9,267 00	6,940 00	....
Jeremiah Adams	Oct. 11, 1895	Extending wall at guard-lock at Glens Falls..	286	1895	10,000 00	8,813 00	....	....
Ira Parker	Aug. 26, 1895	Connecting culvert at Waterford.............	176	1895	2,000 00	1,784 10	1,812 90	....
William J. Dempsey...........	Oct. 9, 1895	Constructing wall and improving Glens Falls feeder	284	1895	8,000 00	5,314 50	3,592 20	....
P. J. Brummelkamp...........	Oct. 23, 1895	Dredging the channel between Shinnecock bay and the Atlantic ocean.................	932	1895	5,200 00	4,000 00	....	....
P. J. Brummelkamp...........	Oct. 23, 1895	Piling and protecting banks, Shinnecock and Peconic canal..............................	932	1895	12,800 00	10,693 00	....	....
P J. Brummelkamp...........	Aug. 30, 1895	Rebuilding sea wall between East Marion and Orient, Suffolk county	838	1895	15,000 00	12,782 50	11,105 00	1,853 00
Frank Pidgeon	Oct. 9, 1895	Repairs to Drake's drawbridge over Wappingers creek, Dutchess county............	1009	1895	3,840 00	3,332 00	....	....

CONCLUSION.

The year 1895 has been an exceptionally busy one for this Department, and as will be seen from the foregoing tables and the reports of the Division Engineers, which are hereto appended, an unusually large amount of work has been accomplished at a relative cost for engineering that will compare favorably with previous records. To do all this has required the best efforts of every employee, and it seems fitting that I should here acknowledge their always willing, loyal and skillful aid.

Respectfully submitted,

CAMPBELL W. ADAMS,

State Engineer and Surveyor.

REPORT

OF

DE WITT C. SMITH,

DIVISION ENGINEER,

EASTERN DIVISION, NEW YORK STATE CANALS,

FOR THE

Fiscal Year Ending September 30, 1895.

APPENDIX B.

ALBANY, N. Y., *October* 1, 1895.

Hon. CAMPBELL W. ADAMS, *State Engineer and Surveyor:*

Sir.—I have the honor to submit the following report on the Eastern Division of the New York State Canals for the fiscal year ending September 30, 1895.

This Division embraces that portion of the Erie Canal with its feeders and sidecuts from the Hudson river at Albany to the dividing line between the Counties of Herkimer and Oneida and the whole of the Champlain Canal with its feeders and sidecuts.

The mileage of canals, feeders and river improvements is as follows:

NAVIGABLE.

	Miles.
Erie Canal, Albany to East line of Oneida Co.	**106.243**
Port Schuyler and West Troy sidecuts	**.350**
Albany Basin	**.770**
Champlain Canal, including Waterford sidecuts:	
Cohoes and Saratoga dams	**66.000**
Pond above Troy dam	**3.000**
Glens Falls feeder and pond	**12.000**
Total	**188.363**

FEEDERS NOT NAVIGABLE.

Mohawk river at Rexford Flats	**.39**
Mohawk river at Rocky Rift	**3.92**
Mohawk river at Little Falls	**.19**
Schoharie Creek	**.63**
Total	**5.13**

WATER SUPPLY.

The Erie canal on this division is supplied with water from the following sources:

That portion west of Little Falls is fed from the Rome *level*; feeders from the Mohawk river enter the canal at Little Falls, Mindenville and Rexford Flats, and from Schoharie Creek at Fort Hunter.

Owing to the excessive drouths prevailing during the season it has been difficult to maintain the standard depth of water at all times, but as the traffic was very light, the quantity of water required for lockage was very much below the average of former seasons. Had the traffic been unusually brisk the conditions would have been very serious.

I would recommend that the subject of storage of water on the tributaries to the Mohawk river be immediately considered, particularly on the West Canada Creek, where large reservoirs can be constructed at a comparatively small cost.

DAMS.

Dam No. 1, is located across the Mohawk river at Rexford Flats. It is a stone masonry dam, and as mentioned in my last report, requires a new apron. An appropriation of $20,000 for that purpose was granted by the last Legislature, plans were prepared and the work advertised, but the bids greatly exceeded the amount appropriated so it was not let. The Superintendent of Public Works, however, removed the old, dilapidated fishway at the southerly end and restored the dam to its former section; he also repaired the abutment.

I would recommend that the next Legislature be asked for an additional appropriation of $15,000 to thoroughly repair this structure. About one hundred lineal feet of the dam, near the middle of the river, was built upon crib work. From careful measurements made during low water this summer, it is shown that this portion has settled about six inches and there is considerable leakage underneath it. Our survey also shows that the bed of the river below the dam, which is composed of shaley bluestone, is being rapidly worn away, leaving deep cavities, and in many places undermining the dam.

This structure should be reinforced, where necessary, by buttresses of masonry and an entire new apron should be built.

Dam No. 2, is located across the Schoharie creek at Fort Hunter. It is a tree dam filled in with gravel. This dam leaks badly and its present condition renders the Schoharie creek of very little value as a feeder to the canal. It received considerable repairing two years ago and was made tight as possible, but the spring freshets washed away the filling, leaving it in as bad condition as before the repairs were made. Owing to its original faulty construction, it will be very difficult, if not impossible, to make any permanent improvement to this structure, and the canal interests would be better conserved by building an entire new dam immediately below the present one.

Dam No. 3, is located across the Mohawk river at Indian Castle. It is a stone dam and is in good condition, but should be raised one foot. This improvement has been previously recommended, and the difficulty experienced this season in maintaining the proper depth of water in the canal has demonstrated that the work should not be delayed any longer. The screen should be removed from between the walls of the bulkhead and a much larger one placed farther up the stream where it would be less liable to clog up; as at present located, the debris carried down by the current lodges against it, forming a barrier which greatly reduces the flow of water.

Dam No. 4, is located across the Mohawk river at Little Falls. It is a new stone masonry dam and is in good condition excepting the gates at the bulkhead, which are badly decayed and should be renewed.

LOCKS.

There are forty-five locks on this division of the Erie canal, two at the West Troy sidecut and two single locks combined at the

Port Schuyler sidecut. Of this number twenty-one have been lengthened.

The masonry in all of the locks on this division need repointing; this has been repeatedly recommended, but thus far little has been done. These structures have been in use for the past fifty years and most of them have received very little attention, and they have now reached that stage of dilapidation that much further neglect will soon render them useless. This is no reflection on their original construction; when the time in which they have been in use and the severe tests to which they have been subjected is considered, it is remarkable that they have stood so well. If they are now thoroughly overhauled, the few broken stones which appear in the faces of the walls replaced with sound ones and the joints carefully cleaned out and filled with Portland cement grout, they can be put in condition to last for many years to come.

In addition to repairs to the masonry mentioned above locks Nos. 4, 8, 13, 17, 21, 35, 42 and 44, require new bottoms. In these locks there is leakage through the floors from one chamber to another which is undermining the structures. The planking should be removed, the voids underneath filled with cement and grout, and entire new floors laid.

AQUEDUCTS.

Four spans of the timber trunk of the Upper Mohawk aqueduct should be rebuilt at once. The trunk of the other ten spans was renewed two years ago, but from lack of sufficient appropriation these four spans were neglected. The timber has been in use for the past eighteen years and is very much decayed, rendering this portion of the structure very dangerous.

The Flat Stone Creek Aqueduct, which was carried away by a break in 1892 and replaced by a temporary structure, has been the source of considerable trouble this season; it is not safe and should be rebuilt.

Lasher's Aqueduct requires some repairs to the masonry, and some new timbers in the trunk.

The Fort Plain aqueduct, which has been mentioned in previous reports as requiring some repairs to the berme abutments, should not be neglected any longer, as its condition is growing worse every year. Trenches should be excavated behind the walls, down to the foundation, the walls should have a heavy backing of concrete and the balance of the trenches filled with puddle.

Two spans of the timber trunk of the Castle Creek aqueduct should be renewed; they are badly decayed and are not safe.

The berme abutments of Fulmer's creek, Steel's creek and Moyer's creek aqueducts should be strengthened with concrete backing. There is considerable leakage through the walls which should be prevented.

The wings of the berme abutments of Ferguson's creek aqueduct must be rebuilt. They have been forced out of plumb by the pressure of the high embankments behind them and are liable to fall at any time.

WASTE WEIRS.

Waste Weir No. 1, located at the westerly end of the Watervliet arsenal grounds requires a new timber bulkhead. The wooden bridge over this structure is very much decayed and should be renewed. The dry vertical wall behind the waste weir, which has fallen down, should be relaid.

Waste Weir No. 2, located under the berme approach to Bridge No. 15, at West Troy, should have entire new woodwork. There is a great deal of leakage through this structure and it should be repaired at once.

Waste Weir No. 7, located near Lock No. 20; No. 8, near Rotterdam Street, Schenectady; No. 15, near Lock 36; and No. 16, about one-fourth mile west of Little Falls, have been closed up for some years past and cannot be used. They are beyond repair and must be rebuilt.

Waste Weir No. 9, located west of Lock No. 27; No. 10, near Lock No. 31; and No. 14, near Fink's Basin, require new woodwork. The east wall of No. 9 should be relaid.

CULVERTS.

There are eighty-four culverts on this division of the Erie canal and about one-half of this number need some repairs, and all of them should be cleaned out. Among those which are in the most dangerous condition and require immediate attention, are Nos. 19, 21, 23, 34, 36, 40, 71, 74 and 84, which should be rebuilt. Nos. 10, 20, 27, 29, 30, 31, 50, 76 and 77 should be partially rebuilt. Several other culverts in which there is considerable leakage through the joints might be repaired by uncovering them and giving them a heavy coating of Portland cement mortar.

DITCHES.

Nearly all the ditches leading from the culverts to the river are filled up with debris and overgrown with bushes. In many cases they are clogged to such an extent as to render the culverts almost useless, leaving no escape for water which during heavy rains is liable to wash away the canal banks or greatly damage adjacent property. There are also innumerable claims for damages to farming lands on account of the overflow from these ditches which destroy the crops and make the land unfit for cultivation. A liberal appropriation should be granted for cleaning them out and restoring them to former usefulness.

BANKS AND PRISMS.

There are no material changes in the condition of the banks and prisms since my last report. A large quantity of sediment was removed from the bottom of the canal before the opening of navigation, and the towing path bank has been raised with gravel, where required, during the summer. A thorough inspection was made before the water was let into the canal last spring and the following table will show the amount, classification and condition of the walls and docking which forms the protection to the banks.

I have a detailed statement giving the location of the different classes of walls and docking, but as it would require too much space for this report, it will be omitted:

TABLE SHOWING CLASSIFICATION, LENGTH AND CONDITION OF WALLS, DOCKING, ETC.

ERIE CANAL.	Towing path. Miles.	Berme. Miles.
Slope wall, good	58.69	28.77
Slope wall, fair	25.96	6.38
Slope wall, poor	4.48	8.29
Dry vertical wall, good	3.83	2.76
Dry vertical wall, fair	2.80	3.37
Dry vertical wall, poor	4.64	7.63
Cement vertical wall, good	0.46	5.79
Cement vertical wall. fair	0.00	0.31
Docking, fair	1.36	1.23
Docking poor	1.86	0.00
No wall at all	0.00	30.80
No wall, rock cut	0.00	6.79
Total	104.08	102.12

NOTE.—Locks, bridge abutments, etc., not included in the above table.

I would renew my recommendation of last year for replacing the old decayed wooden docking on the towing path side west of Schenectady and at the Big Nose with vertical wall and for repairing the vertical wall at the West Troy sidecut, through the Sixteens and through the villages of Mohawk and Ilion. Also the wall at the mouth of the Schoharie creek feeder. About 250 lineal feet of vertical wall should be built on the berme side at the head of Lock No. 19 to enable boats to enter and leave the berme head of this lock with less difficulty and about the same amount of wall should be placed on the towing path side at the foot of Lock 33. The bank at this point is very weak and should be protected.

BRIDGES AND BRIDGE ABUTMENTS.

Four wooden bridges have been rebuilt during this season, viz.: Nos. 37, 95, 123 and the bridge across the feeder at Rexford

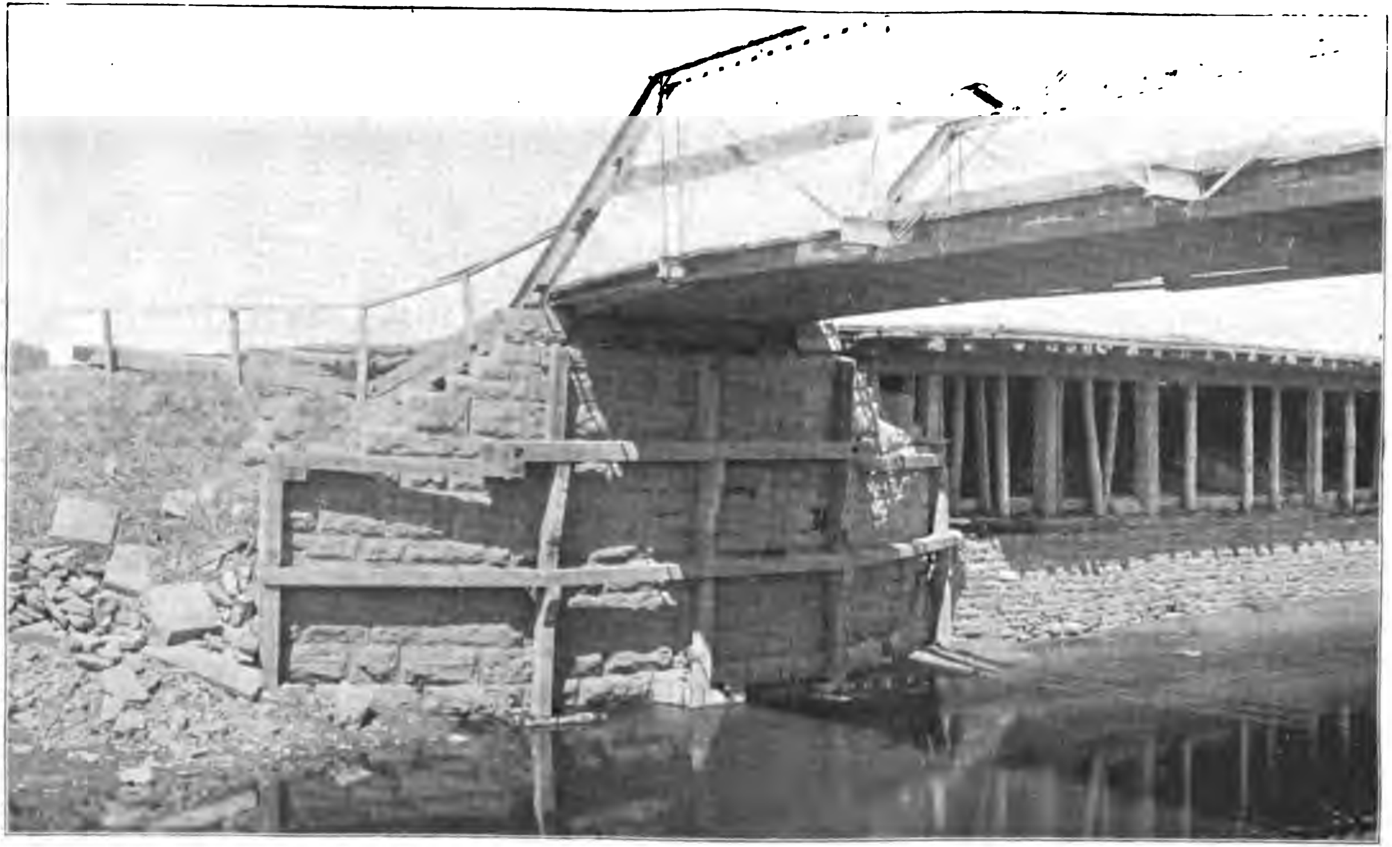
Flats. The old whipple cast iron arch bridge at Manor Ave., Cohoes, has been replaced by a new steel structure.

The abutments on the berme side at the following bridges should be rebuilt, viz.: Nos. 40, 42, 76, 106, 152, 167 and 172. These abutments are all leaning in toward the prism and are liable to fall at any time; they are at present propped up with timbers or tied back with iron rods.

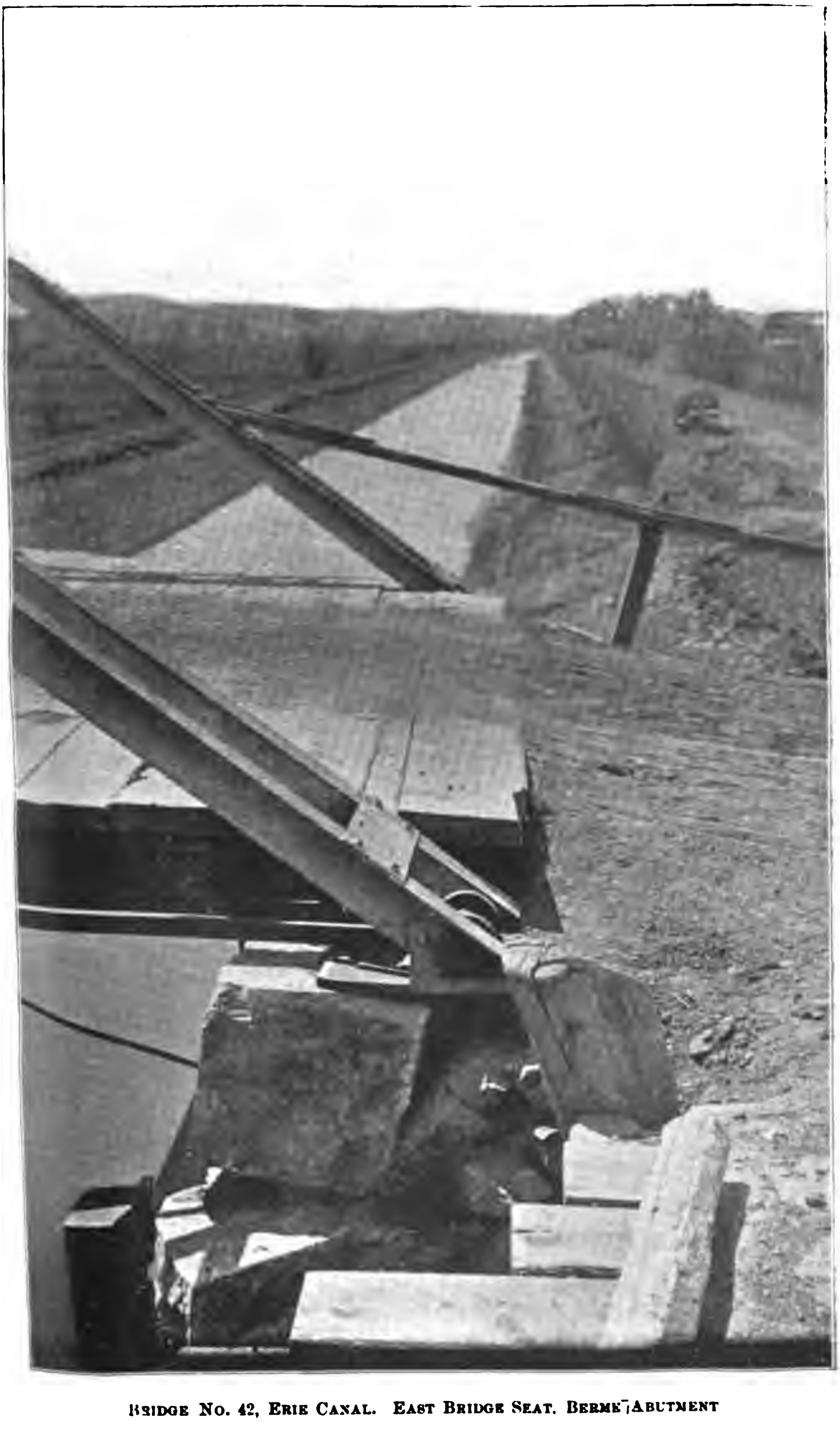
NAVIGATION.

The only serious delay to navigation on this division of the Erie canal this season, was caused by a break in the towing path bank at Culvert 34, about one-fourth mile west of Pattersonville. On the morning of June 5th it was observed that a large volume of water was flowing out of the culvert, and before the level could be drawn down the bank gave way. This occurred about 7 A. M. The boat John L. Nice, loaded with lumber, was caught in the break and completely wrecked. The bank was washed away for a distance of eighty feet, carrying with it a portion of the culvert. As soon as the water had subsided a large force of men and teams were set at work repairing the break and the work was carried on day and night until completed. That portion of the culvert from the inner angle of the towing path to the river which was carried away was replaced by a box culvert, made of timber taken from the wrecked boat, which timber was also used for sheet piling in the embankment. The material used for filling the break was obtained from a field about 2,000 feet distant, together with several car loads of gravel delivered by the West Shore Railroad Co. The work was completed and boats began locking at 4 A. M., June 13th. Total delay of navigation, seven days and twenty-one hours. The amount of materials used was 3,800 cubic yards earth and gravel and 2,700 feet B. M. lumber. There was considerable leakage after the water was let in, which was checked by dumping several boat loads of gravel into the prism.

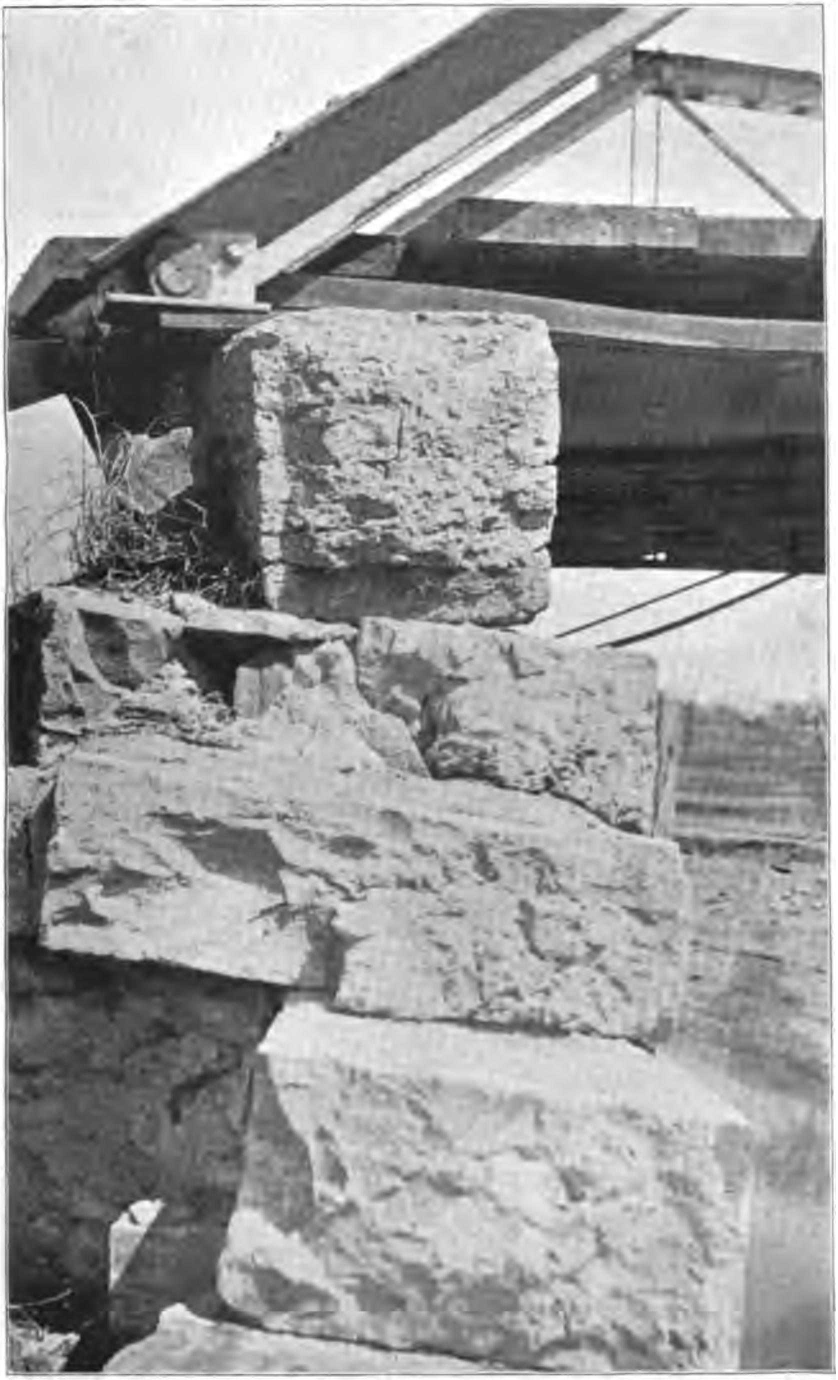
As to the cause of the break it is very difficult to determine, as



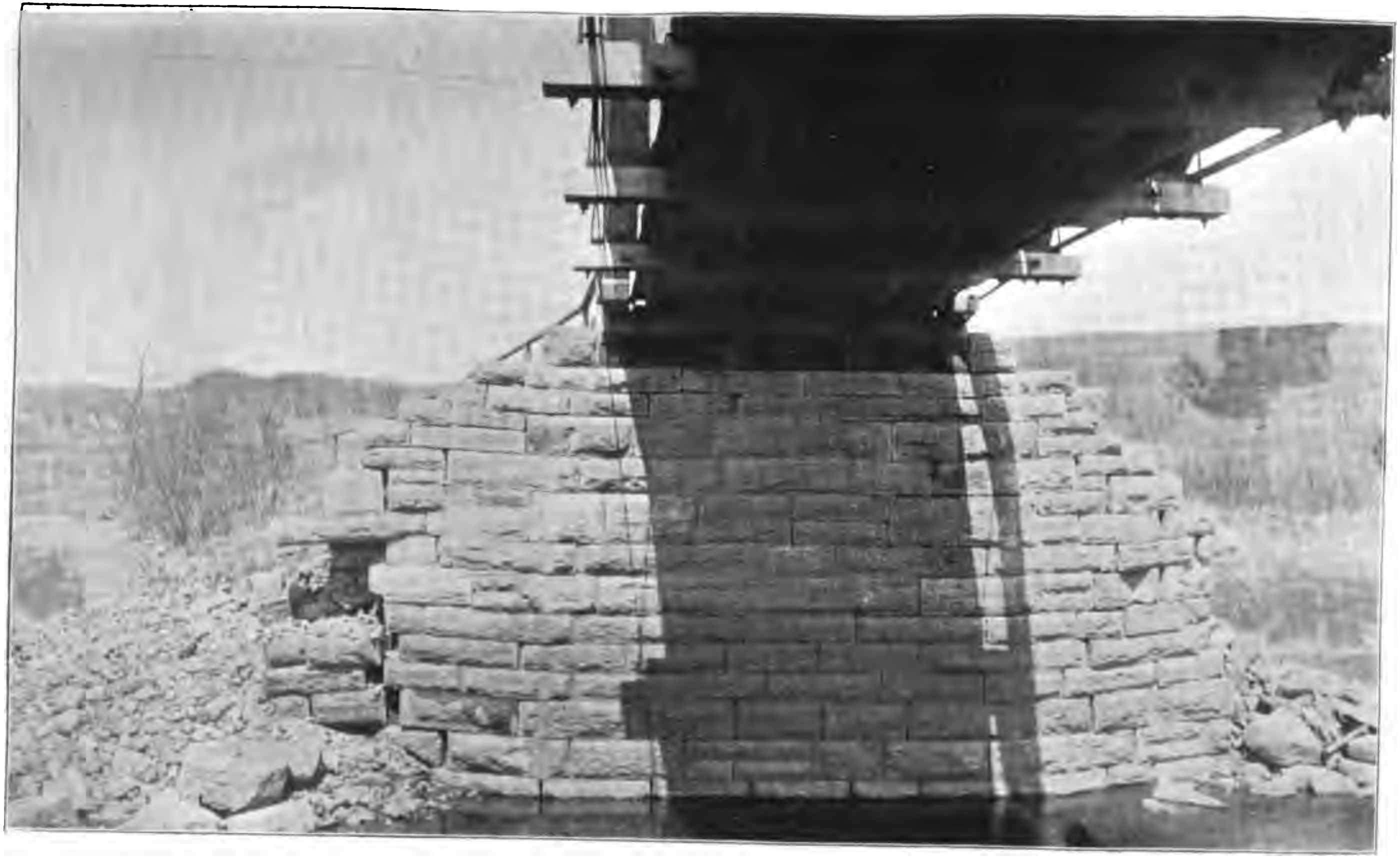
BRIDGE NO. 42, ERIE CANAL. BERME ABUTMENT.



Bridge No. 42, Erie Canal. East Bridge Seat, Berme Abutment



Bridge No. 42, Erie Canal. West Bridge Seat, Berme Abutment.



BRIDGE NO. 30, ERIE CANAL. BERME ABUTMENT,

nothing unusual was noticed here by the bank watch, who daily inspected that portion of the canal, until the morning it gave way. The remaining portion of the culvert appeared to be in good condition. Why the structure failed can only be a matter of conjecture. This culvert must be rebuilt during the coming winter, and I would recommend that it be entirely removed and a thirty-six-inch cast iron pipe substituted.

EXTRAORDINARY REPAIRS, ERIE CANAL,

for lengthening Lock No. 20. The contract for lengthening the berme lock at the foot and building 480 lineal feet of vertical wall on the berme side was awarded to John Twomey, July 24th, 1894. The work was completed on May 1st, 1895. The contract for furnishing machinery for drawing boats into the lock was awarded to W. B. Wemple Sons.

Chapter 572, Laws of 1894—appropriation, $40,000.

This act also appropriated $100,000 for deepening a portion of the Erie canal to a depth of nine feet and repairing structures. Plans were prepared for deepening the canal between Locks 1 and 2 by excavating one foot from the bottom and raising the banks one foot and repairing Lock 1, but so many objections were raised by the owners of the property known as the Lumber District against raising the banks which would involve a very large expense to them in raising the piers on which the lumber is piled, to correspond with the increased height of the canal, that the work was not let excepting that portion relating to Lock No. 1, the contract for which was let to Cunningham, Monty, Johnson and Hilt. The work consisted in building a cofferdam across the mouth of the channel leading into the river, pumping the water out of the lock pit, taking up the floor and apron, filling the voids underneath with concrete and puddle, putting in an entire new floor, miter sills and bumping beams, repairing the gates and repointing the masonry. The lock is now in good condition.

ROCKY RIFT FEEDER.

Chapter 655, Laws of 1894—appropriation, $8,000,

which was expended in rebuilding the culvert under Castle creek. The contract was let to the Troy Public Works Co., August 25th, 1894, and was completed in March, 1895. This improvement increases the area of waterway at this point from 96 to 210 square feet.

FORT HERKIMER WASTE WEIR.

Chapter 77, Laws of 1895—appropriation, $5,000.

The contract for rebuilding the Fort Herkimer Waste Weir was awarded to Michael Bennett, March 21st, 1895, and the work was completed in time for the opening of navigation, May 5th. This was a much needed improvement as the old structure was in a very dilapidated state; it was partially undermined, and the space where the bulkhead should be was filled with old barrels of cement, the joints between them caulked with hay and the whole covered over with gravel.

It required constant care to prevent a serious break here during the season of navigation.

MANOR AVENUE BRIDGE.

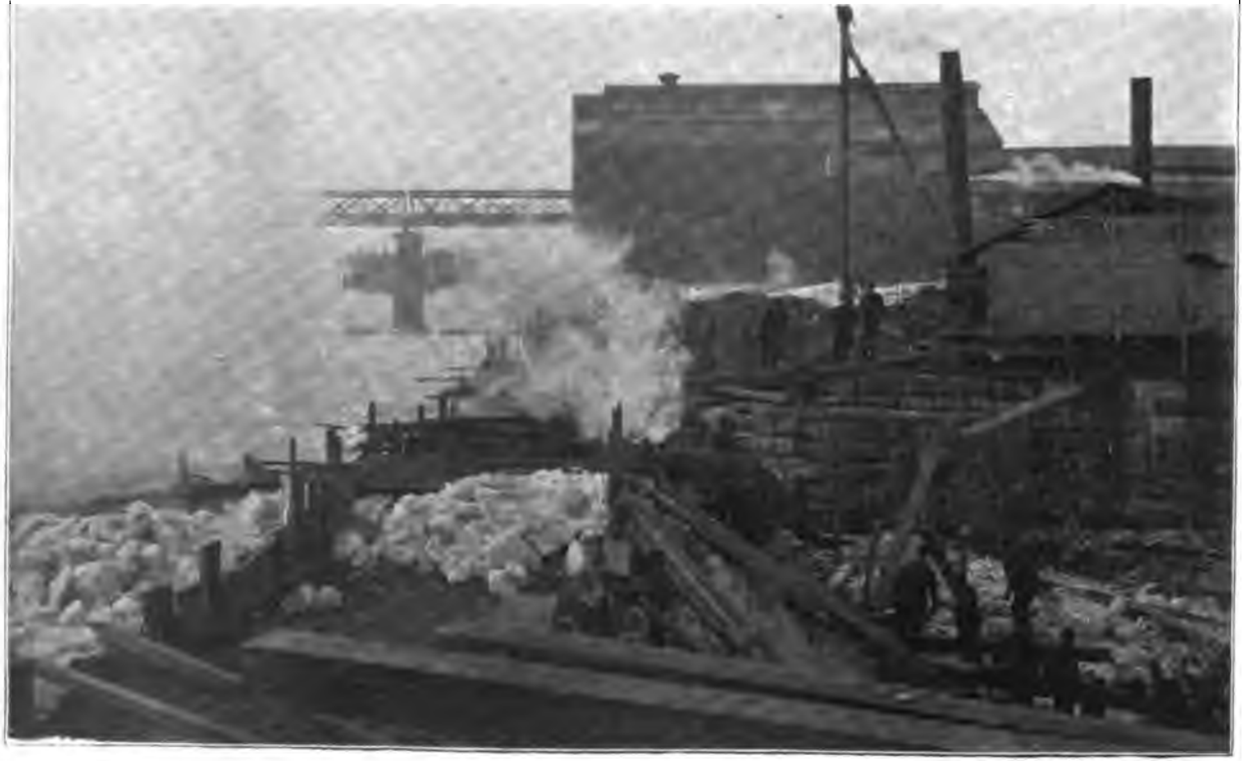
Chapter 139, Laws of 1895—appropriation, $4,000.

The contract for constructing a steel bridge over the Erie canal at Manor Avenue, Cohoes, was let to the Hilton Bridge Company, April 13th, 1895, and was completed July 15th.

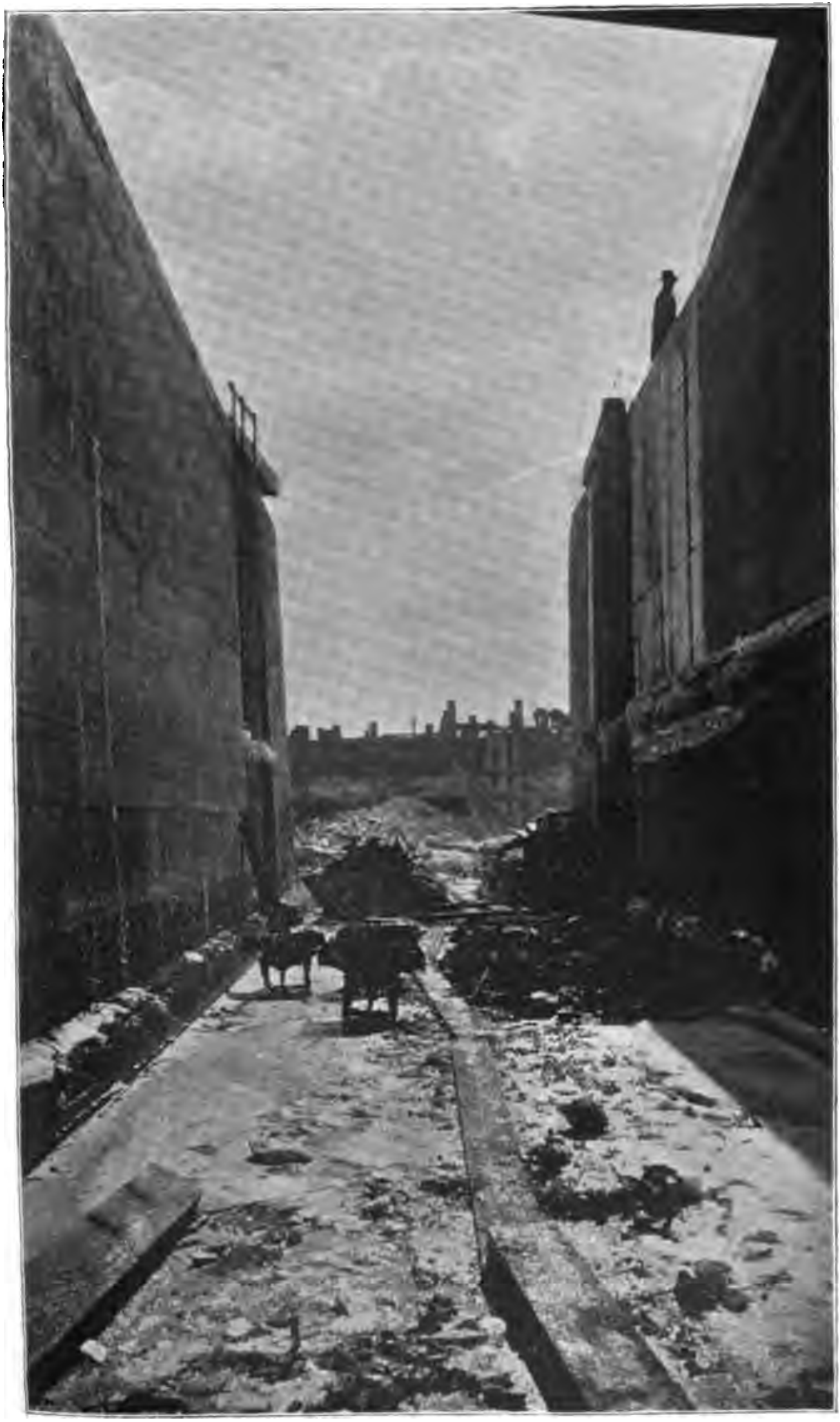
HIGH STREET BRIDGE.

Chapter 141, Laws of 1895—appropriation, $4,000.

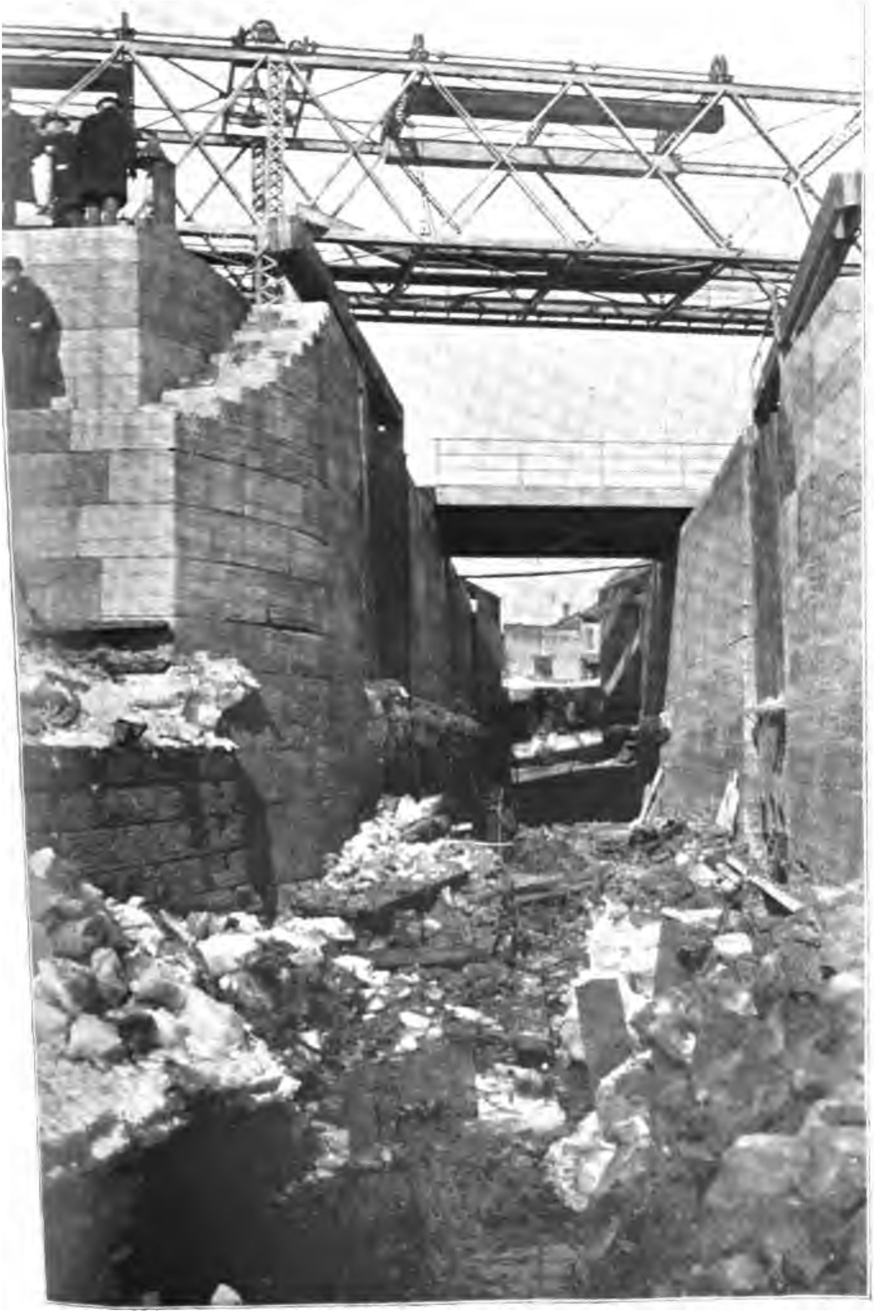
The contract for constructing a steel bridge over the Erie canal at High Street, Cohoes, in place of the present dilapidated structure, was awarded to the Groton Bridge Company, April 13th, 1895. Owing to the difficulty the contractors experienced in get-



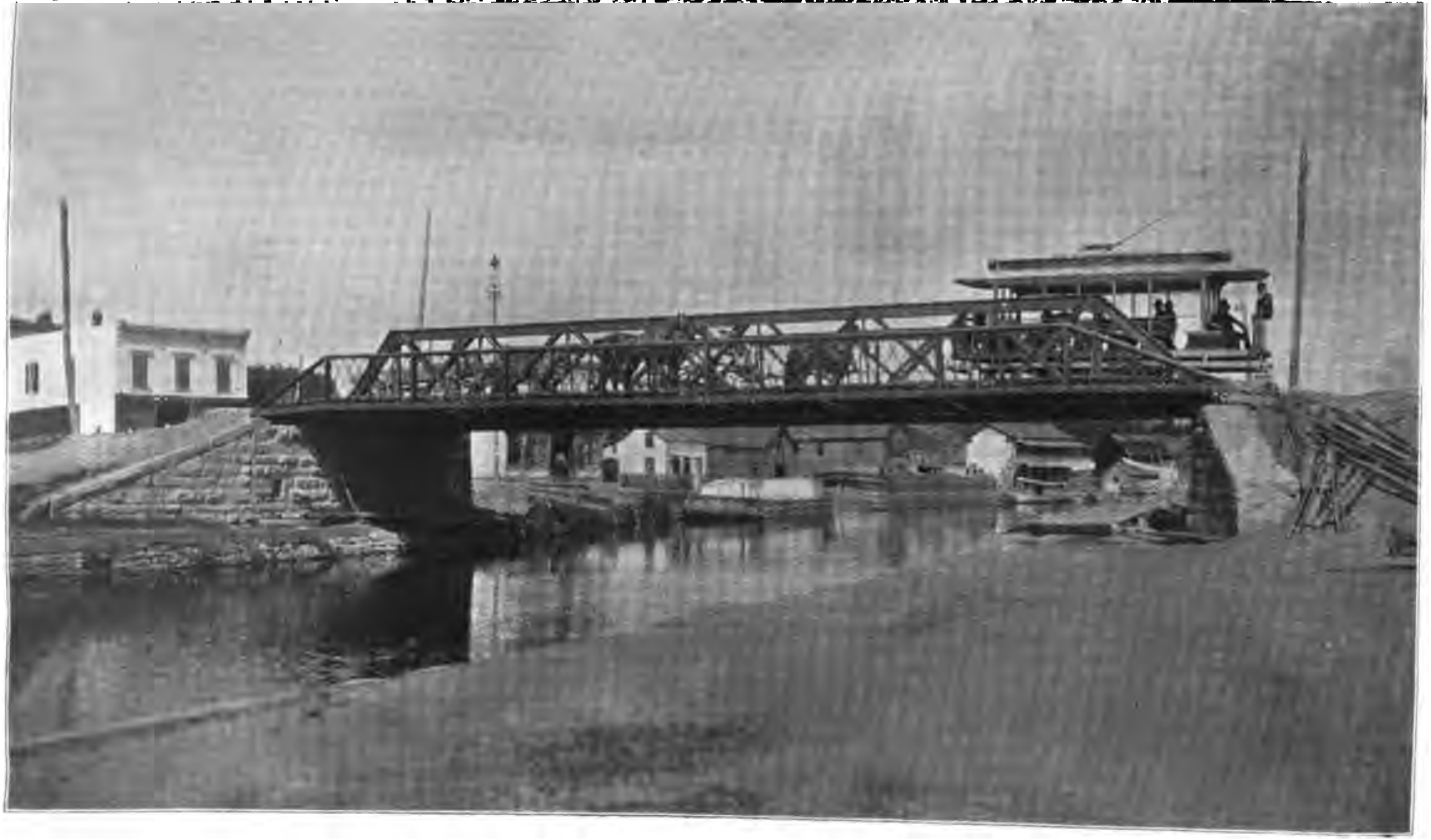
COFFER DAM. LOCK NO. 1.



North Chamber Lock No. 1. Looking East.



North Chamber Lock No. 1. Looking West.



Manor Avenue Bridge, Cohoes, N. Y.

ting the material from the rolling mills, the bridge has not yet been erected.

LOCKS No. 21 AND 22.

Chapter 320, Laws of 1895

This act appropriated $77,500 for lengthening Locks 21 and 22. Surveys were made and plans prepared, but owing to the location of Lock No. 22, the lengthening of which would require changing the prism between the two locks, the work was not advertised, as the estimated cost of the whole improvement exceeded the appropriation.

REXFORD FLATS DAM.

Chapter 560, Laws of 1895—appropriation, $20,000.

This appropriation was for building a new apron to the Rexford Flats dam. Plans were prepared and the work advertised, but as the bids greatly exceeded the appropriation, it was not let.

SCHENECTADY WALL.

Chapter 288, Laws of 1895—appropriation, $2,089.84.

This act appropriated an unexpended balance on work done under chapter 495, Laws of 1892, for rebuilding the retaining wall on the berme side of the canal in the city of Schenectady, between the Union Street bridge and the Arcade Building. The work was done under the directions of the Superintendent of Public Works.

SIDEWALKS AT STATE STREET BRIDGE.

Chapter 492, Laws of 1895—appropriation, $2,000.

This act provides for rebuilding the sidewalks on the bridge over the Erie canal at State Street in the city of Schenectady. The bridge proper was rebuilt by the Schenectady Street Railway Company in 1892, and the old sidewalks attached to it, and as mentioned in my last report, are unsafe. Plans have been prepared for new sidewalks.

GERMAN STREET BRIDGE.

Chapter 680, Laws of 1895—appropriation, $8,000.

This act provides for the rebuilding of the bridge over the Erie canal at German Street in the city of Little Falls, for which plans have been prepared.

DREDGING ALBANY BASIN.

Chapter 963, Laws of 1895—appropriation, $15,000.

This act provides for dredging the Albany Basin to a depth not exceeding ten feet. The contract was let to P. W. Meyers & Son, August 26th, and the work is now under way.

DREDGING WEST TROY BASIN.

Chapter 966, Laws of 1895—appropriation, $3,000.

This act provides for dredging the West Troy Basin to a depth not exceeding seven feet. The work was done under the direction of the Superintendent of Public Works.

Champlain Canal.

WATER SUPPLY.

The water supply of the Champlain canal is as follows:—

That portion between the junction with the Erie canal and Lock No. 5, is taken from the Mohawk river at Cohoes; between Lock No. 5 and Lock No. 10, the supply is taken from the Hudson river at Northumberland; the balance of the canal is supplied from the Hudson river through the Glens Falls feeder, discharging into the summit level at Fort Edward, supplemented on the north by the waters of Wood creek. The supply has not been adequate at all times during the season. The rivers have been unusually low, and there is an immense leakage through the Glens Falls feeder and through imperfect structures along the canal. From careful gaugings taken this summer by Mr. George W. Rafter, it is shown that less than 50 per cent. of the water taken into the feeder reaches the canal. This vast leakage is not only a drawback to navigation, but a serious detriment to the manufacturing interests located along the river. The leakage is principally through the crevices of the rock which forms the bed of the feeder through the village of Glens Falls. Several attempts have been made to remedy this evil, but they have not proved successful. The bottom of the prisms should be cleaned down to rock, and covered with a bed of concrete, made of crushed stone and asphalt cement. The work is of considerable magnitude and a special appropriation of $20,000 should be granted for that purpose.

LOCKS.

There are eighteen lift and five guard locks on the Champlain canal—three lift locks combined on the Waterford sidecut and thirteen lift and one guard lock on the Glens Falls feeder.

Locks 6, 9 and 16 must be rebuilt; the masonry in these structures has bulged in toward the chambers, so that it is very difficult for boats to pass through them. The faces of the walls in Lock No. 6 had to be cut back from two to five inches before the opening of navigation last spring. Several boats have wedged in Locks 9 and 16 this season causing considerable delay, and one boat was injured to such an extent in Lock 9 that it sunk as soon as it left the lock. An inspection of the plans from which these structures were built indicates that the walls are not heavy enough to withstand the pressure of the embankments behind them, especially during freezing weather. They have usually been braced apart with heavy timbers after the close of navigation each year, but in spite of this precaution the masonry has been forced so much out of line it is impracticable to repair them.

In my last report I suggested that they might be repaired by cutting back the faces of the walls to give the chambers the proper dimensions, and that excavations be made behind the walls down to the foundations and the walls reinforced with a backing of concrete, but from careful measurements made after the close of navigation the structures were found to be in a worse condition than anticipated. The masonry is not first-class and will not admit of being cut back to the extent necessary to give the chambers the proper size. The only remedy is to rebuild them.

DAMS.

There are seven dams on the Champlain canal and one at the head of the Glens Falls feeder; they are all in very good condition excepting No. 1, which is located across the Hudson river at Troy. This structure, which is a timber crib dam filled with stones with an apron of the same character, has been reported as unsafe for several years past, and quite a large break occurred there three years ago, which was repaired by dropping cribs filled with stone into the opening. The whole structure received considerable repairing at that time, but from the badly decayed condition of the timbers it is impracticable to make any permanent improvement in it, and measures should be considered for building a new dam before the present one fails.

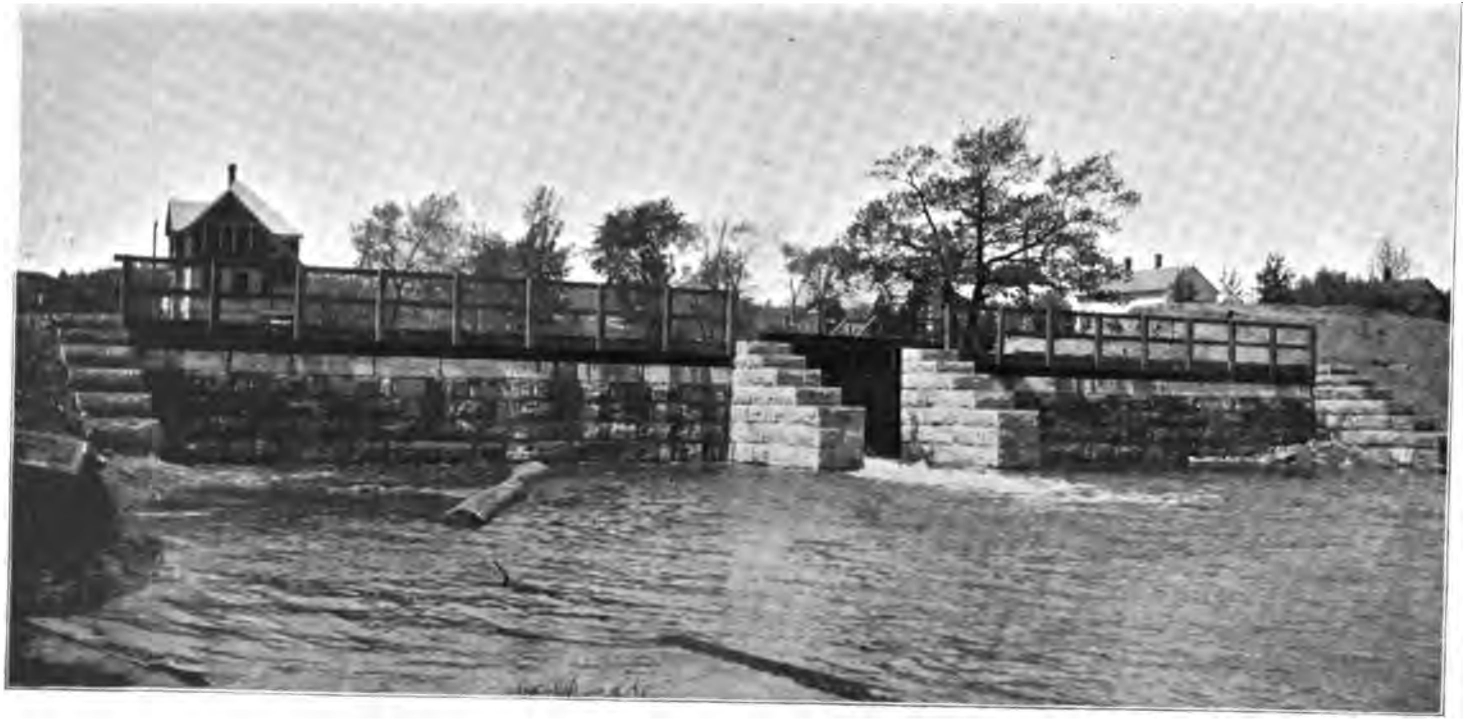
AQUEDUCTS.

There are four aqueducts on the Champlain canal. No. 1, located over Fish creek in the village of Schuylerville, needs some new timbers in the trunk, and the north towing path abutment, which has settled considerably, should be taken down and relaid.

No. 2, located above Lock No. 12, is a single span aqueduct. A portion of the masonry on the towing path side should be relaid and new timbers are required in the trunk.

No. 3, located at Moses Kill, above Lock No. 14. The abutments should be partially taken down and relaid and the trunk requires some new timbers.

No. 4, located at Fort Edward, needs a new timber trunk.



Lansing's Waste Weir, Stillwater, N. Y.

WASTE WEIRS.

There are twenty-eight waste weirs and spillways on this canal and one-fourth of them should be rebuilt at once; they are very much dilapidated and unfit for use. Their respective locations are as follows:—

Just below lock 7; between lock 7 and 8; north of lock 8; Mechanicville; Wilbur's Basin; between locks 13 and 14 and south of Smith's Basin between bridges 105 and 106; also the one on the Glens Falls feeder, near Finch & Pruyn's lime kiln. These structures have nearly all been referred to in previous reports and their condition is yearly growing worse. They are beyond repair, some of them are entirely closed up, leaving no means of controlling the water in case of breaks or heavy rains.

Lansing's waste weir at Stillwater was rebuilt last winter; it is a substantial structure of cut stone masonry with steel bulkhead.

The remaining waste weirs nearly all require new woodwork.

CULVERTS.

There are twenty-five culverts on the Champlain canal and two on the Glens Falls feeder. With a few exceptions they are in fair condition, though most of them need cleaning out. The culvert opposite Burton's waste weir, the one located above bridge 11, and Walker's culvert at Whitehall are unsafe and should be rebuilt.

BANKS AND PRISMS.

The banks and prisms of the Champlain canal remain about as stated in my last report, excepting one mile from the Bemis Heights waste weir northerly, which was reconstructed last winter to the standard section of forty-four feet width at bottom and six feet depth of water. About one-half of this canal is now thus improved. On the unimproved portion where the banks are not protected by either walls or docking, they are gradually slidcement works. The contract was awarded to Flood & Sherrill, July 23d, 1894. The work was completed April 30th, 1895.

BASIN STREET BRIDGE.

Chapter 105, Laws of 1895—appropriation, $3,500.

This act provided for building a bridge and abutments at Basin street, Sandy Hill. The contract was let to Dempsey, Reilly and Reardon, April 13th, 1895. The work was completed August 15th.

SCHUYLERVILLE WALL.

Chapter 105, Laws of 1895—appropriation, $12,000.

This act provides for building a vertical wall along the berme bank of the Champlain canal in the village of Schuylerville. The contract was awarded to Cunningham and Monty, August 26th, 1895.

CEMETERY CULVERT.

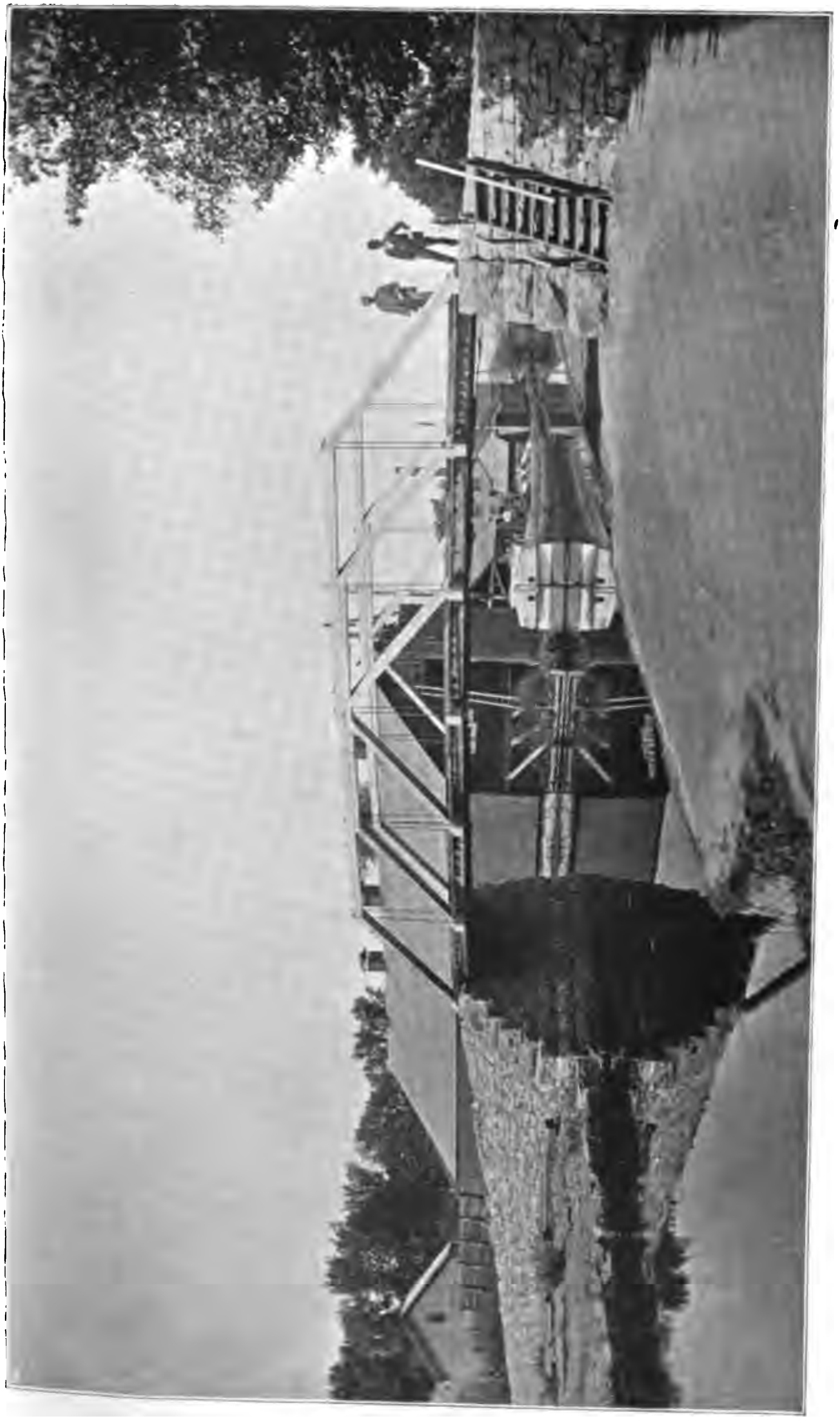
Chapter 176, Laws of 1895—appropriation, $2,000.

For lengthening both ends of the culvert over the Cemetery creek in the village of Waterford. The contract was let to Ira Parker, August 26th, 1895.

IMPROVING GLENS FALLS FEEDER.

Chapter 284, Laws of 1895, appropriates $8,000

for building a vertical wall on the berme side of the Glens Falls feeder between Maple street and Pearl street in the village of Sandy Hill. And chapter 286, Laws of 1895, appropriates $10,000 for extending the retaining wall at the guard lock and other improvements on the feeder. Plans have been prepared for the walls and for rebuilding the Maple street bridge and berme abutment.



Basin St. Bridge, Sandy Hill, N. Y

RAISING THE TOWING PATH.

Chapter 298, Laws of 1895, appropriates $10,000

for raising the towing path between Smith's and Dunham's Basin. The work is being done by the Superintendent of Public Works.

SHINNECOCK AND PECONIC CANAL.

Chapter 358, Laws of 1894—appropriation, $3,500.

For restoring and protecting the approaches to the swing bridge over the Shinnecock and Peconic canal, and chapter 768, Laws of 1894, appropriated $15,000 for protecting the banks of said canal, and, as stated in my last report, both contracts were awarded to P. J. Brummelkamp. The work under said contracts was completed in December, 1894. The cost of the work was considerably increased on account of a severe storm which occurred soon after the piling was completed up to the Long Island railroad bridge. The storm drove the waters in from Peconic bay, and in passing through the contracted channel under said bridge produced a scour which undermined the piling and washed considerable of it away. The canal bottom at that point was washed out to a depth of thirty feet. The returning tides filled it up again nearly to its normal condition. The break was repaired by driving triple lap sheet piling to a depth of forty feet; it has since remained all right.

Chapter 932, Laws of 1895, appropriated $12,800 for completing the work on the canal, and $5,200 for dredging a channel from Shinnecock bay to the ocean, for which plans have been prepared.

SEA WALL.

Chapter 838, Laws of 1895, appropriated $15,000

for rebuilding the sea wall for protecting the highway from encroachments of the sea between East Marion and Orient, in the county of Suffolk. The contract was awarded to P. J. Brummelkamp, August 30th. The work is now under way.

DRAKE'S DRAWBRIDGE.

Chapter 1009, Laws of 1895—appropriated $3,840.50

for rebuilding the center pier of the drawbridge over Wappinger's creek, on the village of New Hamburgh, and repairing the bridge. Plans have been prepared.

MOLE AT HOUGHTALING ISLAND.

Chapter 358, Laws of 1894.

This act appropriated $1,200 for building a roadway from the State dykes along Houghtaling Island to connect with the island. The contract was awarded to Wm. Fuller, July 23d, 1894, and the work was completed the following November.

SARANAC RIVER IMPROVEMENT.

Chapter 169, Laws of 1894—appropriation, $4,000.

This act provided for completing the work of removing from the Saranac river, between the dam at Saranac lake village and Miller's pond, all trees, stumps, etc. The work was done by the Superintendent of Public Works.

UPPER HUDSON RIVER SURVEY.

Chapter 599, Laws of 1895—appropriation, $8,000.

This act provides for making surveys of the upper Hudson river valley with a view of determining what lakes and streams may be improved or the waters thereof stored or diverted in order to provide for the enlargement of the Champlain canal, for restoring to the water powers of the Hudson river at or below Glens Falls the water diverted therefrom for canal purposes, and for improving the navigation of the lower Hudson river. The work is in charge of Mr. Geo. W. Rafter, who is at present engaged in making the surveys.

ENGINEERING DEPARTMENT.

This division during the last fiscal year has been in charge of the undersigned as Division Engineer; Mr. Albert J. Himes as Resident Engineer; Mr. T. C. Leutze, Mr. John R. Kaley and Mr. C. C. Heustis, Assistant Engineers. Mr. Leutze and party have been engaged a considerable portion of the time, under the direction of the Attorney-General, in making surveys and maps and giving expert testimony before the State Board of Claims in defense of suits brought against the State. Mr. Kaley, during the greater portion of the year, has been detailed on work under the Quarantine Commissioners in the enlargement of Hoffman Island.

This Department has furnished plans for and superintended the construction of a reservoir for the storage of water at Dannemora prison. An earth embankment dam with paved side slopes and masonry core was built across a ravine forming a reservoir with a capacity of 1,500,000 gallons, which is supplied by springs flowing from the mountains. All manual labor was performed by convicts. The reservoir insures an abundant supply of pure water for the prison, and also gives adequate protection against fire.

We have frequently been called upon by the Department of Public Works for plans and estimates for work on ordinary repairs to the canals, and have also done some work for the Capitol Commissioners.

The amount and variety of work and the wide extent of territory over which it has been distributed, required quite a large force of men and made the expense for travel somewhat heavy, but they have in all cases been kept as low as the circumstances would permit.

Tables are hereto annexed, showing in detail the engineering expenses of the division, the names of the persons employed, time of service and compensation of each; also tables showing the contracts completed and final accounts rendered during the year, and contracts pending September 30th, 1895.

Respectfully submitted,

DE WITT C. SMITH,
Division Engineer.

TABLE OF CONTRACTS ON EASTERN DIVISION COMPLETED DURING THE YEAR ENDING SEPTEMBER 30, 1895.

NAME OF CONTRACTOR.	Date of contract.	CHARACTER OF WORK.	Appropriation.	LEGISLATIVE ACT.		Engineer's estimate at contract prices.	Final estimate.	Remarks.
				Chapter.	Year.			
			ERIE CANAL.					
Troy Public Works Co.	Aug. 25, 1894	Repairs to Rocky Rift Feeder	$8,000 00	655	1894	$7,405 50	$7,407 66	
Cunningham, Monty, Johnson & Hilt	Dec. 28, 1894	Repairs to Lock No 1	100,000 00	572	1894	8,536 50	9,591 26	
John Twomey	July 24, 1894	Lengthening Lock No. 20	40,000 00	572	1894	34,294 65	35,030 89	
Wm. B. Wemple's Sons	July 24, 1894	Machinery for Lock No. 20	....	572	1894	1,200 00	1,200 00	
Michael Bennett	Mar. 21, 1895	Repairs to Fort Herkimer waste weir	5,000 00	67	1895	3,564 70	4,303 02	
Hilton Bridge Constr. Co.	April 15, 1895	Manor Ave bridge, Cohoes	4,000 00	139	1895	2,883 00	3,617 94	
			CHAMPLAIN CANAL.					
Cunningham & Monty	Aug. 4, 1893	Repairing Cohoes dam	110,000 00	643 462	1893 1894	87,389 00	104,314 86	
Hilton Bridge Constr. Co.	Nov. 20, 1894	Superstructures bridges 39 and 40	56,000 00	572	1894	1,450 00	1,450 00	
Pidgeon & Co.	Dec. 27, 1894	Rebuilding Lansing's waste weir	56,000 00	572	1891	9,542 20	10,437 95	
Troy Public Works Co.	Nov. 2, 1894	Improving 5,200 lineal feet of the Champlain canal from Bemis Heights waste weir northerly	56,000 00	572	1894	35,385 25	35,891 24	
Troy Public Works Co.	Nov. 2, 1894	Abutments and approaches to North street bridge, Mechanicville	7,000 00	594	1894	3,155 20	3,603 54	
Wrought Iron Bridge Co.	Nov. 13, 1894	Superstructure North st. bridge, Mechanicville	....	594	1894	1,600 00	1 600 00	
John Twomey	Dec. 17, 1894	Conveying waters of the Ensign brook	1,500 00	593	1891	1,021 40	965 60	
Flood & Sherrill	July 23, 1894	Vertical wall at Glens Falls Feeder	15,000 00	278	1894	9,124 86	9,612 16	
Reilly, Reardon & Dempsey	April 13, 1895	Basin st. bridge, Sandy Hill	3,500 00	143	1895	2,197 10	2,821 85	
			SHINNECOCK AND PECONIC CANAL.					
P. J. Brummelkamp	July 24, 1894	Approaches to swing bridge over Shinnecock and Peconic canal	3,500 00	358	1894	2,793 70	3,018 30	
P. J. Brummelkamp	July 23, 1894	Piling and protecting banks	15,000 00	768	1894	12,547 80	13,003 09	
			HUDSON RIVER.					
William D. Fuller	July 23, 1894	Mole at Houghtaling Island	1,200 00	358	1891	935 00	930 56	

The foregoing tables are summarized as follows:

ORDINARY REPAIRS.		
Erie Canal, chapter 297, Laws of 1894	$8,968 98	
Champlain Canal, chapter 297, Laws of 1894	4,323 36	
		$13,292 34
EXTRAORDINARY REPAIRS.		
Deepening Erie Canal, chapter 119, Laws of 1893, and chapter 572, Laws of 1894	$1,327 50	
Repairing Cohoes Dam, chapter 643, Laws of 1893, and chapter 462, Laws of 1894	565 38	
Improving Saranac River, chapter 169, Laws of 1894	152 77	
Repairs to Glens Falls Feeder, chapter 278 Laws of 1894	1,144 43	
Shinnecock and Peconic Canal, chapters 358 and 768, Laws of 1894, and chapter 932, Laws of 1895	835 07	
Improving Champlain Canal, chapter 572, Laws of 1894	3,959 26	
Lengthening Lock No. 20, Erie Canal, chapter 572, Laws of 1894	3,042 09	
Repairs to Lock No. 1 Erie Canal, chapter 572, Laws of 1894	715 65	
Bridges Nos. 39 and 40, Champlain Canal, chapter 572, Laws of 1894	159 77	
Lansing's Waste Weir, chapter 572, Laws of 1894	919 80	
Canajoharie Lift Bridge, chapter 592, Laws of 1894	48 00	
Ensign Brook, Champlain Canal, chapter 593, Laws of 1894	110 55	
North Street Bridge, Mechanicville, chapter 594, Laws of 1894	672 70	
Rocky Rift Feeder, chapter 655, Laws of 1894	238 41	
Fort Herkimer Waste Weir chapter 67, Laws of 1895	447 64	
Wall at Schuylerville, chapter 105, Laws of 1895	403 13	
Manor Avenue Bridge, Cohoes, chapter 139, Laws of 1895	348 96	
High Street Bridge, Cohoes, chapter 141, Laws of 1895	350 39	
Basin Street Bridge, Sandy Hill, chapter 143, Laws of 1895	301 00	
Cemetery Culvert, Waterford, chapter 176, Laws of 1895	87 55	
Repairs to Glens Falls Feeder chapter 284, Laws of 1895	102 15	
Wall at Glens Falls Feeder, chapter 286, Laws of 1895	555 58	
Schenectady Wall, chapter 288, Laws of 1895	100 60	
Tow Path, Smith's Basin, Champlain Canal, chapter 298, Laws of 1895	1,173 33	
Lengthening Locks 21 and 22, Erie Canal, chapter 320, Laws of 1895	832 14	
Repairs to Rexford Flats Dam, chapter 560, Laws of 1895	597 11	
Sea Wall at Orient, chapter 838, Laws of 1895	1,025 51	
Dredging Albany Basin, chapter 963, Laws of 1895	947 70	
Dredging West Troy Basin chapter 966, Laws of 1895	254 90	
Drake's Draw Bridge, chapter 1009, Laws of 1895	79 43	
		$21,498 50
SPECIAL SURVEYS.		
Making Surveys and Maps for use of the State Board of Claims	$4,482 95	
Making Surveys and Maps required by State Engineer and Surveyor, chapter 358, Laws of 1895	1,297 41	
Upper Hudson River Survey, chapter 599, Laws of 1895	3,920 41	
		9,700 77
Total		$44,491 61

TABLE OF CONTRACTS PENDING ON THE EASTERN DIVISION SEPTEMBER 30, 1895.

NAME OF CONTRACTOR.	Date of contract.	CHARACTER OF WORK.	Appropriation.	LEGISLATIVE ACT.		Engineer's preliminary estimate.	Engineer's estimate at contract prices.	Payments to date.
				Chapter.	Year.			
		ERIE CANAL.						
Groton Bridge Co.	April 13, 1895	High st. bridge, Cohoes	$4,000 00	141	1395	$3,557 00	$3,367 00	....
P. W. Myers & Son	Aug. 26, 1895	Dredging Albany basin	15,000 00	963	1895	12,600 00	9,513 00	$2,482 00
		CHAMPLAIN CANAL.						
Cunningham & Monty	Aug. 26, 1895	Repairing berme bank, Schuylerville	12,000 00	105	1895	9,267 00	6,940 00	....
Jeremiah Adams	Oct. 11, 1895	Extending wall at guard lock, etc., at Glens Falls feeder	10 000 00	286	1895	8,813 10	....	....
Ira Parker	Aug. 26, 1895	Cemetery culvert at Waterford	2,000 00	176	1895	1,784 10	1,812 90	....
William J. Dempsey	Oct. 9, 1895	Constructing wall on berme bank and improving Glens Falls feeder	8,000 00	284	1895	5,314 50	3,592 20	....
		SHINNECOCK AND PECONIC CANAL.						
P. J. Brummelkamp	Oct. 23, 1895	Dredging the channel between Shinnecook bay and the Atlantic ocean	5,200 00	932	1895	4,000 00	....	....
P. J. Brummelkamp	Oct. 23, 1895	Piling and protecting banks	12,800 00	932	1895	10,693 40	....	....
		SEA WALL AT ORIENT.						
P. J. Brummelkamp	Aug. 30, 1895	Rebuilding sea wall between East Marion and Orient, Suffolk Co., N. Y.	15,000 00	838	1895	12,782 50	11,105 00	1,858 00
		HUDSON RIVER.						
Frank Pidgeon	Oct. 9, 1895	Repairs to Drake draw bridge over Wappinger creek, Dutchess Co., N. Y.	3,840 50	1009	1895	3,332 00	....	....

Statement showing names, rank, number of days and compensation of Engineers employed on the Eastern Division of the New York State Canals, together with incidental expenses during the fiscal year ending September 30, 1895.

(No. 1.)

ORDINARY REPAIRS—ERIE CANAL.

CHAPTER 297, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
De Witt C. Smith	Division engineer	....	$2,400 00 per year	$1,599 96	$299 09	$1,899 05
Albert J. Himes	Resident engineer	....	2,000 00 per year	709 80	192 22	902 02
T. C. Leutze	Assistant engineer in charge	24	6 00 per day	144 00	43 76	187 76
John R Kaley	Assistant engineer in charge	8	6 00 per day	48 00	3 00	51 00
C. C. Huestis	Assistant engineer	27	5 00 per day	135 00	16 00	151 00
Dorion Clark	Leveler	70	4 50 per day	315 00	134 66	449 66
C. H Flanigan	Leveler	54	4 50 per day	243 00	24 81	267 81
T A. Hendrickson	Leveler	21	4 50 per day	94 50	22 66	117 16
C. M. Pepeon	Rodman	103	3 50 per day	360 50	43 26	403 76
F. N. Sanders	Rodman	....	3 50 per day	....	31 12	31 12
A. M. Evans	Rodman	49	3 50 per day	171 50	....	171 50
F. A. Bagg	Rodman	27	4 00 per day	108 00	....	108 00
Eugene H. Lilly	Chainman	240	3 50 per day	840 00	37 91	877 91
H. J. Richardson	Chainman	67	2 50 per day	167 50	58 61	226 11
Frank Lutz	Chainman	21	2 50 per day	52 50	9 40	61 90
F. D. Haak	Chainman	80	4 00 per day	320 00	7 15	327 15
Henry F. Smith	Chainman	77	3 50 per day	269 50	12 05	281 55
William J. Gilmore	Chainman	14	2 50 per day	35 00	7 10	42 10
C. A. Cockroft	Chainman	2	4 50 per day	9 00	14 41	23 41
L. B. Jones	Chainman	145	2 50 per day	362 50	121 39	483 89
Guy H. Miller	Chainman	84	2 50 per day	210 00	9 18	219 18
H. C. Copeland	Chainman	10	2 50 per day	25 00	5 87	30 87
George M. Lilly	Laborer	4	2 50 per day	10 00	11 54	21 54
						$7,335 40
INCIDENTAL EXPENSES.						
Office rent					$12 50	
Fuel and light					1 00	
Livery					217 50	
Labor					248 37	
Postage and telegraph					219 00	
Stationery					502 68	
Miscellaneous					432 53	
						1,633 58
						$8,968 98

ORDINARY REPAIRS.—CHAMPLAIN CANAL.

CHAPTER 297, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
De Witt C. Smith	Division engineer		$2,400 00 per year	$800 04	$78 40	$878 44
Albert J. Himes	Resident engineer		2,000 00 per year	21 72	7 65	29 37
T. C. Leutze	Assistant engineer in charge	10	6 00 per day	60 00	40 88	100 88
John R. Kaley	Assistant engineer in charge	5	6 00 per day	30 00	14 26	44 26
T. A. Hendrickson	Leveler	16	4 50 per day	72 00	26 84	98 84
C. M. Pepson	Rodman	36	3 50 per day	126 00	9 00	135 00
F. N. Sanders	Rodman	28	3 50 per day	98 00	3 41	101 41
A. M. Evans	Rodman	132	3 50 per day	462 00	6 42	468 42
F. A. Bagg	Rodman	3	4 00 per day	12 00	3 25	15 25
F. J. Lempe	Rodman	27	3 50 per day	94 50	....	94 50
Eugene H. Lilly	Chainman	24	3 50 per day	84 00	....	84 00
H. J. Richardson	Chainman	33	2 50 per day	82 50	....	82 50
Frank Lutz	Chainman	9	2 50 per day	22 50	6 00	28 50
Fred D. Haak	Chainman	231	4 00 per day	924 00	....	924 00
Henry F. Smith	Chainman	36	3 50 per day	126 00	1 10	127 10
William J. Gilmore	Chainman	24	2 50 per day	60 00	6 00	66 00
C. A. Cockroft	Chainman	26	4 50 per day	117 00	8 97	125 97
Guy H. Miller	Chainman	34	2 50 per day	85 00	11 58	96 58
H. C. Copeland	Chainman	12	2 50 per day	30 00	2 70	32 70
George McDonald	Chainman	34	2 50 per day	85 00	12 85	97 85
Ralph Russell	Chainman	15	2 50 per day	37 50	....	37 50
William Van Epps	Laborer	7	2 50 per day	17 50	6 00	23 50
						$3,692 57

INCIDENTAL EXPENSES.

Office rent	$9 00	
Livery	184 00	
Labor	47 43	
Postage and telegraph	116 13	
Stationery	200 70	
Miscellaneous	123 53	
		630 79
		$4,323 36

DEEPENING ERIE CANAL.

CHAPTER 119, LAWS OF 1893, AND CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
T. C. Leutze	Assistant engineer in charge	30	$6 00 per day	$180 00	$35 67	$215 67
Dorlon Clark	Leveler	35	4 50 per day	157 50	34 68	192 18
C. H. Flanigan	Leveler	48	4 50 per day	216 00	15 92	231 92
C. M. Pepson	Rodman	38	3 50 per day	133 00	19 71	152 71
F. S. Strong	Rodman	15	3 50 per day	52 50	5 56	58 06
H. J. Richardson	Chainman	34	2 50 per day	85 00	14 01	99 01
Frank Lutz	Chainman	39	2 50 per day	97 50	22 50	120 00
Henry F. Smith	Chainman	14	3 50 per day	49 00	9 00	58 00
William J. Gilmore	Chainman	19	2 50 per day	47 50	11 20	58 70
James Thomson	Chainman	14	2 50 per day	35 00	3 46	38 46
William Van Epps	Laborer	22	2 50 per day	55 00	14 80	69 80
						$1,294 51
INCIDENTAL EXPENSES.						
Fuel					$2 00	
Postage and telegraph					80	
Labor					50	
Miscellaneous					29 69	
						32 99
						$1,327 50

(No. 16.)

ROCKY RIFT FEEDER.

CHAPTER 655, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$10 86	$10 06	$20 92
T. C. Leutze	Ass't engineer in charge	4	6 00 per day	24 00	18 34	42 34
Dorlon Clark	Leveler	1	4 50 per day	4 50	4 46	8 96
C. H. Flanigan	Leveler	4	4 50 per day	18 00	2 98	20 98
A. M. Evans	Rodman	2	3 50 per day	7 00	3 96	10 96
C. M. Pepson	Rodman	2	3 50 per day	7 00	1 52	8 52
H. J. Richardson	Chainman	2	2 50 per day	5 00	8 27	13 27
Frank Lutz	Chainman	1	2 50 per day	2 50	3 96	6 46
Henry F. Smith	Chainman	29	3 50 per day	101 50	3 50	105 00
						$237 41
INCIDENTAL EXPENSES.						
Postage and telegraph					50	
Miscellaneous					50	1 00
						$238 41

(No. 29.)

SEA WALL AT ORIENT.

CHAPTER 838, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$71 37	$51 82	$123 19
T. C. Leutze	Assistant engineer in charge	23	6 00 per day	138 00	149 95	287 95
Dorlon Clark	Leveler	15	4 50 per day	67 50	49 70	117 20
F. S. Strong	Rodman	13	3 50 per day	45 50	57 35	102 85
Frank Lutz	Chainman	6	2 50 per day	15 00	18 25	33 25
H. J. Richardson	Chainman	10	2 50 per day	25 00	51 98	76 98
Ralph Russell	Chainman	6	2 50 per day	15 00	20 51	35 51
Guy H. Miller	Chainman	25	2 50 per day	62 50	68 58	131 08
Henry F. Smith	Chainman	22	3 50 per day	77 00	40 50	117 50
						$1,025 51

(No. 5.)

IMPROVING SARANAC RIVER.

CHAPTER 169, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
De Witt C Smith	Division engineer	....	$2,400 00 per year	....	$34 17	$34 17
Albert J Himes	Resident engineer	....	2,000 00 per year	$21 72	20 80	42 52
T. C. Leutze	Assistant engineer in charge	5	6 00 per day	30 00	46 08	76 08
						$152 77

(No 7.)

SHINNECOCK AND PECONIC CANAL.

CHAPTERS 358 AND 768, LAWS OF 1894, AND CHAPTER 932, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
T. C. Leutze	Ass't engineer in charge	2	$6 00 per day	$12 00	$24 56	$36 56
A. M. Evans	Rodman	20	3 50 per day	70 00	....	70 00
C. A. Cockroft	Chainman	61	4 50 per day	274 50	69 35	343 85
William J. Gilmore	Chainman	12	2 50 per day	30 00	36 91	66 91
L. B. Jones	Chainman	103	2 50 per day	257 50	33 56	291 06
						$808 38
INCIDENTAL EXPENSES.						
Office rent					$20 00	
Postage and telegraph					5 94	
Miscellaneous					75	
						26 69
						$835 07

(No. 20.)

HIGH STREET BRIDGE, COHOES.

CHAPTER 141, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Dorlon Clark	Leveler	16	$4 50 per day	$72 00	$3 50	$75 50
A. M. Evans	Rodman	2	3 50 per day	7 00	2 89	9 89
Eugene H. Lilly	Chainman	27	3 50 per day	94 50		94 50
L. B. Jones	Chainman	12	2 50 per day	30 00	13 00	43 00
H. J. Richardson	Chainman	6	2 50 per day	15 00	....	15 00
William J. Gilmore	Chainman	10	2 50 per day	25 00	....	25 00
George P. Hilton	Draughtsman	....	....	87 50	....	87 50
						$350 39

(No. 19.)

MANOR AVENUE BRIDGE, COHOES.

CHAPTER 139, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$32 94	$4 83	$37 77
T. C. Leutze	Ass't engineer in charge	6	6 00 per day	36 00	4 35	40 35
Dorlon Clark	Leveler	2	4 50 per day	9 00	2 00	11 00
F. S. Strong	Rodman	27	3 50 per day	94 50	2 52	97 02
L. B. Jones	Chainman	5	2 50 per day	12 50	6 60	19 10
H. J. Richardson	Chainman	10	2 50 per day	25 00	9 50	34 50
Henry F. Smith	Chainman	2	3 50 per day	7 00	2 20	9 20
Arthur O'Brien	Chainman	27	3 50 per day	94 50	2 52	97 02
						$345 96
INCIDENTAL EXPENSES.						
Livery					$3 00	3 00
						$348 96

(No. 23.)

REPAIRS TO GLENS FALLS FEEDER.

CHAPTER 284, LAWS OF 1893.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
F. J. Lempe	Rodman	5	$3 50 per day	$17 50	$21 65	$39 15
George McDonald	Chainman	5	2 50 per day	12 50	8 00	20 50
Arthur O'Brien	Chainman	8	3 50 per day	28 00	14 50	42 50
						$102 15

EXTRAORDINARY REPAIRS ERIE CANAL—LENGTHENING LOCKS 21 AND 22.

CHAPTER 320, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$21 72	$9 79	$31 51
T. C. Leutze	Ass't engineer in charge	9	6 00 per day	54 00	35 73	89 73
C. C. Huestis	Assistant engineer	40	5 00 per day	200 00	3 29	203 29
Dorlon Clark	Leveler	15	4 50 per day	67 50	21 44	88 94
A. M. Evans	Rodman	25	3 50 per day	87 50	....	87 50
C. M. Pepson	Rodman	10	3 50 per day	35 00	15 40	50 40
F. A. Bagg	Rodman	6	4 00 per day	24 00	6 27	30 27
L. B. Jones	Chainman	12	2 50 per day	30 00	19 43	49 43
H. J. Richardson	Chainman	16	2 50 per day	40 00	22 52	62 52
Henry F. Smith	Chainman	10	3 50 per day	35 00	14 15	49 15
Ralph Russell	Chainman	12	2 50 per day	30 00	20 68	50 68
Frank Lutz	Chainman	6	2 50 per day	15 00	5 22	20 22
						$813 64
INCIDENTAL EXPENSES.						
Livery					$12 00	
Miscellaneous					6 50	18 50
						$832 14

(No. 21.)

BASIN STREET BRIDGE, SANDY HILL.

CHAPTER 143, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel	Total.
Albert J. Himes	Resident engineer		$2,000 00 per year	$22 02	$16 17	$38 19
T. C. Leutze	Ass't engineer in charge	7	6 00 per day	42 00	24 33	66 33
T. A. Hendrickson	Leveler	23	4 50 per day	103 50	30 56	134 06
Dorion Clark	Leveler	1	4 50 per day	4 50	4 48	8 98
George McDonald	Chainman	14	2 50 per day	35 00	14 44	49 44
						$297 00
INCIDENTAL EXPENSES.						
Office rent					$4 00	4 00
						$301 00

(No. 25.)

SCHENECTADY WALL.

CHAPTER 288, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
A. M. Evans	Rodman	21	$3 50 per day	$73 50	$27 10	$100 60
						$100 60

LANSING'S WASTE WEIR.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$38 43	$6 75	$45 18
John R. Kaley	Ass't engineer in charge	15	6 00 per day	90 00	9 89	99 89
Dorlon Clark	Leveler	1	4 50 per day	4 50	2 20	6 70
F. A. Bagg	Rodman	28	4 00 per day	112 00	1 50	113 50
F. N. Sanders	Rodman	28	3 50 per day	98 00	....	98 00
C. M. Pepson	Rodman	2	3 50 per day	7 00	....	7 00
H. J. Richardson	Chainman	20	2 50 per day	50 00	1 10	51 10
Guy H. Miller	Chainman	51	2 50 per day	127 50	9 95	137 45
C. A. Cockroft	Chainman	26	4 50 per day	117 00	4 50	121 50
Henry F. Smith	Chainman	15	3 50 per day	52 50	....	52 50
Frank Lutz	Chainman	27	2 50 per day	67 50	50	68 00
						$800 82

INCIDENTAL EXPENSES.

Labor	$28 98	
Livery	63 00	
Postage and telegraph	7 00	
Office rent	19 00	
Miscellaneous	1 00	
		118 98
		$919 80

(No. 9.)

EXTRAORDINARY REPAIRS—ERIE CANAL—LENGTHENING LOCK 20.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident Engineer	....	$2,000 00 per year	$183 64	$38 51	$222 15
T. C. Leutze	Ass't engineer in charge	17	6 00 per day	102 00	43 89	145 89
C. C. Huestis	Assistant engineer	132	5 00 per day	660 00	48 17	708 17
Dorlon Clark	Leveler	1	4 50 per day	4 50	1 98	6 48
C. M. Pepson	Rodman	5	3 50 per day	17 50	5 53	23 03
F. S. Strong	Rodman	134	3 50 per day	469 00	1 15	470 15
F. J. Lempe	Rodman	161	3 50 per day	563 50	2 52	566 02
L. B. Jones	Chainman	1	2 50 per day	2 50	1 30	3 80
Arthur O'Brien	Chainman	57	3 50 per day	199 50	4 77	204 27
H. J. Richardson	Chainman	1	2 50 per day	2 50	1 55	4 05
William Van Epps	Laborer	84	2 50 per day	210 00	1 10	211 10
						$2,565 11
INCIDENTAL EXPENSES.						
Fuel					$6 06	
Stationery					70 55	
Labor					90	
Livery					366 00	
Postage and telegraph					3 60	
Miscellaneous					29 87	
						476 98
						$3,042 09

(No. 6.)

REPAIRING GLENS FALLS FEEDER.

CHAPTER 278, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$71 55	$35 22	$106 77
T. C. Leutze	Ass't engineer in charge	14	6 00 per day	84 00	61 89	145 89
C. A. Cockroft	Chainman	95	4 50 per day	427 50	55 06	482 56
Frank Lutz	Chainman	2	2 50 per day	5 00	7 11	12 11
William J. Gilmore	Chainman	122	2 50 per day	305 00	37 39	342 39
H. J. Richardson	Chainman	2	2 50 per day	5 00	7 39	12 39
						$1,102 11
INCIDENTAL EXPENSES.						
Office rent					$30 00	
Livery					5 00	
Postage and telegraph					2 25	
Miscellaneous					5 07	
						42 32
						$1,144 43

(No. 17.)

REPAIRS TO FORT HERKIMER WASTE WEIR.

CHAPTER 67, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$77 10	$56 80	$133 90
T. C. Leutze	Ass't engineer in charge	5	6 00 per day	30 00	21 56	51 56
A. M. Evans	Rodman	4	3 50 per day	14 00	12 72	26 72
H. J. Richardson	Chainman	2	2 50 per day	5 00	9 48	14 48
Henry F. Smith	Chainman	32	3 50 per day	112 00	13 45	125 45
Fred. D. Haak	Chainman	2	4 00 per day	8 00	6 48	14 48
Guy H. Miller	Chainman	28	2 50 per day	70 00	6 91	76 91
						$443 50
INCIDENTAL EXPENSES.						
Postage and telegraph					$1 44	
Miscellaneous					2 70	
						4 14
						$447 64

(No. 29.)

CEMETERY CULVERT, WATERFORD.

CHAPTER 176, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
F. J. Lempe	Rodman	5	$3 50 per day	$17 50	$3 30	$20 80
F. S. Strong	Rodman	4	3 50 per day	14 00	4 40	18 40
George McDonald	Chainman	5	2 50 per day	12 50	5 85	18 35
Arthur O'Brien	Chainman	7	3 50 per day	24 50	5 50	30 00
						$87 55

(No. 32.)

DRAKE'S DRAWBRIDGE.

CHAPTER 1009, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$10 86	$4 27	$15 13
T. C. Leutze	Ass't engineer in charge	3	6 00 per day	18 00	4 57	22 57
Dorlon Clark	Leveler	2	4 50 per day	9 00	4 07	13 07
F. S. Strong	Rodman	2	3 50 per day	7 00	3 82	10 82
H. J. Richardson	Chainman	2	2 50 per day	5 00	4 02	9 02
Frank Lutz	Chainman	2	2 50 per day	5 00	3 82	8 82
						$79 43

(No. 26.)

TOWPATH, SMITH'S BASIN, CHAMPLAIN CANAL.

Chapter 298, Laws of 1895.

Name.	Rank.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$136 17	$42 02	$178 19
T. C. Leutze	Ass't engineer in charge	6	6 00 per day	36 00	19 02	55 02
Dorlon Clark	Leveler	12	4 50 per day	54 00	21 91	75 91
F. S. Strong	Rodman	13	3 50 per day	45 50	22 86	68 36
Guy H. Miller	Chainman	25	2 50 per day	62 50	....	62 50
H. J. Richardson	Chainman	12	2 50 per day	30 00	28 77	58 77
William J. Gilmore	Chainman	25	2 50 per day	62 50	2 53	65 03
George McDonald	Chainman	52	2 50 per day	130 00	19 23	149 23
Ralph Russell	Chainman	52	2 50 per day	130 00	178 66	308 66
Frank Lutz	Chainman	19	2 50 per day	47 50	23 09	70 59
						$1,087 26

Incidental Expenses.

Livery	$10 50	
Stationery	59 98	
Postage and telegraph	1 99	
Miscellaneous	13 60	
		86 07
		$1,173 33

EXTRAORDINARY REPAIRS—CHAMPLAIN CANAL.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$186 60	$43 24	$229 84
John R. Kaley	Ass't engineer in charge	46	6 00 per day	276 00	60 69	336 69
F. A. Bagg	Rodman	164	4 00 per day	656 00	30 01	686 01
F. N. Sanders	Rodman	134	3 50 per day	469 00	9 50	478 50
A. M. Evans	Rodman	31	3 50 per day	108 50	....	108 50
H. J. Richardson	Chainman	1	2 50 per day	2 50	1 70	4 20
C. A. Cockroft	Chainman	18	4 50 per day	81 00	14 22	95 23
Henry F. Smith	Chainman	2	3 50 per day	7 00	....	7 00
Frank Lutz	Chainman	94	2 50 per day	235 00	5 55	240 55
George McDonald	Chainman	79	2 50 per day	197 50	18 84	216 34
Ralph Russell	Chainman	144	2 50 per day	360 00	24 55	384 55
John Hackett	Chainman	89	2 50 per day	222 50	16 35	238 85
Arthur O'Brien	Chainman	64	3 50 per day	224 00	4 50	228 50
William J. Gilmore	Chainman	19	2 50 per day	47 50	8 70	56 20
						$3,310 95

INCIDENTAL EXPENSES.

Fuel	$1 98	
Stationery	62 23	
Labor	33 50	
Livery	424 50	
Postage and telegraph	6 94	
Office rent	58 00	
Miscellaneous	61 16	
		648 31
		$3,959 26

(No. 10.)

REPAIRS TO LOCK NO. 1, ERIE CANAL.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$83 25	....	$83 25
T. C. Leutze	Ass't engineer in charge	25	6 00 per day	150 00	....	150 00
Dorlon Clark	Leveler	61	4 50 per day	274 50	....	274 50
C. M. Pepson	Rodman	25	3 50 per day	87 50	....	87 50
H. J. Richardson	Chainman	1	2 50 per day	2 50	....	2 50
Eugene H. Lilly	Chainman	27	3 50 per day	94 50	....	94 50
						$692 25
INCIDENTAL EXPENSES.						
Office rent					$10 00	
Miscellaneous					13 40	
						23 40
						$715 65

(No. 28.)

REPAIRS TO REXFORD FLATS DAM.

CHAPTER 560, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$87 42	$16 91	$104 33
C. C. Huestis	Assistant engineer	64	5 00 per day	320 00	9 57	329 57
Dorlon Clark	Leveler	1	4 50 per day	4 50	1 80	6 30
F. N. Sanders	Rodman	4	3 50 per day	14 00	4 90	18 90
C. M. Pepson	Rodman	10	3 50 per day	35 00	10 38	45 38
F. J. Lempe	Rodman	2	3 50 per day	7 00	3 10	10 10
Henry F. Smith	Chainman	16	3 50 per day	56 00	14 10	70 10
						$584 68

INCIDENTAL EXPENSES.

Labor	$11 28	
Miscellaneous	1 15	
		12 43
		$597 11

(No. 18.)

WALL AT SCHUYLERVILLE.

CHAPTER 105, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2.000 00 per year	$59 73	$13 21	$72 94
T. C. Leutze	Ass't engineer in charge	7	6 00 per day	42 00	17 57	59 57
Dorlon Clark	Leveler	13	4 50 per day	58 50	14 14	72 64
F. S. Strong	Rodman	13	3 50 per day	45 50	14 52	60 02
Ralph Russell	Chainman	12	2 50 per day	30 00	14 17	44 17
H. J. Richardson	Chainman	13	2 50 per day	32 50	14 97	47 47
Frank Lutz	Chainman	13	2 50 per day	32 50	13 82	46 32
						$403 13

(No. 24.)

WALL AT GLENS FALLS FEEDER.

CHAPTER 286, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
T. C. Leutze	Ass't engineer in charge	2	$6 00 per day	$12 00	$6 01	$18 01
F. J. Lempe	Rodman	40	3 50 per day	140 00	16 15	156 15
William J. Gilmore	Chainman	62	2 50 per day	155 00	45 60	200 60
George McDonald	Chainman	8	2 50 per day	20 00	18 16	38 16
Arthur O'Brien	Chainman	37	3 50 per day	129 50	11 91	141 41
						$554 33
INCIDENTAL EXPENSES.						
Miscellaneous					$1 25	1 25
						$555 58

(No. 15.)

NORTH STREET BRIDGE, MECHANICVILLE.

CHAPTER 594, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$38 85	$9 82	$48 67
T. C. Leutze	Ass't engineer in charge	14	6 00 per day	84 00	27 23	111 23
T. A. Hendrickson	Leveler	50	4 50 per day	225 00	37 77	262 77
George McDonald	Chainman	50	2 50 per day	125 00	3 63	128 63
H. J. Richardson	Chainman	1	2 50 per day	2 50	1 95	4 45
						$555 75
INCIDENTAL EXPENSES.						
Postage and telegraph					$2 40	
Office rent					14 00	
Labor					100 00	
Miscellaneous					55	
						116 95
						$672 70

(No. 14.)

ENSIGN BROOK, CHAMPLAIN CANAL.

CHAPTER 593, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
George McDonald	Chainman	42	$2 50 per day	$105 00	$5 55	$110 55

(No. 13.)

CANAJOHARIE LIFT BRIDGE.

CHAPTER 592, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
T. C. Leutze	Ass't engineer in charge	8	$6 00 per day	$48 00	....	$48 00

(No. 34.)

EXAMINATIONS AND MAPS.

CHAPTER 358, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	... .	$2,000 00 per year	$38 85	$39 04	$77 89
Frank Lutz	Chainman	6	2 50 per day	15 00	5 99	20 99
John J. Allen	Chainman	297	4 00 per day	1,188 00	10 53	1,198 53
						$1,297 41

(No. 30.)

DREDGING ALBANY BASIN.

CHAPTER 963, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
T. C. Leutze	Ass't engineer in charge	3	$6 00 per day	$18 00	....	$18 00
Dorlon Clark	Leveler	19	4 50 per day	85 50	....	85 50
A. M. Evans	Rodman	25	3 50 per day	87 50	....	87 50
F. N. Sanders	Rodman	37	3 50 per day	129 50	....	129 50
C. M. Pepson	Rodman	40	3 50 per day	140 00	....	140 00
F. A. Bagg	Rodman	32	4 00 per day	128 00	....	128 00
H. J. Richardson	Chainman	18	2 50 per day	45 00	....	45 00
Henry F. Smith	Chainman	63	3 50 per day	220 50	$3 50	224 00
Frank Lutz	Chainman	19	2 50 per day	47 50	....	47 50
						$905 00
INCIDENTAL EXPENSES.						
Office rent					$5 00	
Labor					10 75	
Miscellaneous					26 95	
						42 70
						$947 70

(No. 31.)

DREDGING WEST TROY BASIN.

CHAPTER 966, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
F. A. Bagg	Rodman	17	$4 00 per day	$68 00	$2 50	$70 50
C. M. Pepson	Rodman	29	3 50 per day	101 50	3 50	105 00
George McDonald	Chainman	27	2 50 per day	67 50	3 70	71 20
						$246 70
INCIDENTAL EXPENSES.						
Labor					$6 00	
Miscellaneous					2 20	
						8 20
						$254 90

(No. 11.)

BRIDGES NOS. 39 AND 40, CHAMPLAIN CANAL.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Albert J. Himes	Resident engineer	....	$2,000 00 per year	$104 97	$11 50	$116 47
T. C. Leutze	Ass't engineer in charge	5	6 00 per day	30 00	9 10	39 10
L. B. Jones	Chainman	1	2 50 per day	2 50	1 70	4 20
						$159 77

(No. 35.)

UPPER HUDSON RIVER SURVEY.

CHAPTER 599, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
DeWitt C. Smith	Division engineer	....	$2,400 00 per year	....	$94 28	$94 28
George W. Rafter	Engineer in charge	60	10 00 per day	$600 00	344 87	344 97
Wallace Greenalch	Leveler	43	4 50 per day	193 50	45 04	238 54
F. N. Sanders	Rodman	52	3 50 per day	182 00	152 52	334 52
F. S. Strong	Rodman	14	3 50 per day	49 00	11 95	60 95
Arthur O'Brien	Chainman	45	3 50 per day	157 50	21 97	179 47
Frank Pelon	Axeman	....	....	44 48	....	44 48
Gustavus Bentley	Axeman	....	....	46 70	....	46 70
J. H. Jennings	....	....	....	....	442 37	442 37
Frank Sutton	....	....	....	....	360 16	360 16
W. M. Beaman	....	....	....	....	164 13	164 13
Austin A. Ross	....	....	....	....	249 89	249 89
H. G. Locke	....	....	....	....	169 08	169 08
D. E. Farrington	....	....	....	....	164 00	164 00
						$3,493 39

INCIDENTAL EXPENSES.

Miscellaneous	$129 45	
Stationery	16 00	
Postage and telegraph	3 71	
Labor	48 00	
W. & L. E. Gurley	229 86	
		427 02
		$3,920 41

(No. 33.) SPECIAL SURVEYS—STATE BOARD OF CLAIMS.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
T. C. Leutze	Ass't engineer in charge	136	$6 00 per day	$816 00	$737 59	$1,553 59
Dorion Clark	Leveler	62	4 50 per day	279 00	139 05	418 05
T. A. Hendrickson	Leveler	30	4 50 per day	135 00	135 32	270 32
F. S. Strong	Rodman	52	3 50 per day	182 00	82 00	264 00
A. M. Evans	Rodman	17	3 50 per day	59 50	21 70	81 20
F. J. Lempe	Rodman	27	3 50 per day	94 50	52 14	146 64
Frank Lutz	Chainman	57	2 50 per day	142 50	96 26	238 76
William J. Gilmore	Chainman	12	2 50 per day	30 00	26 18	56 18
H. J. Richardson	Chainman	76	2 50 per day	190 00	230 54	420 54
Arthur O'Brien	Chainman	13	3 50 per day	45 50	20 74	66 24
Ralph Russell	Chainman	74	2 50 per day	185 00	162 03	347 03
James Thomson	Chainman	12	2 50 per day	30 00	20 05	50 05
L. B. Jones	Chainman	42	2 50 per day	105 00	107 99	212 99
Henry F. Smith	Chainman	3	3 50 per day	10 50	6 94	17 44
						$4,143 03
INCIDENTAL EXPENSES.						
Livery					$61 50	
Postage and telegraph					35 77	
Labor					18 50	
Miscellaneous					224 15	$339 92
						$4,482 95

(No. 4.)

REPAIRING COHOES DAM.

CHAPTER 643, LAWS 1893, AND CHAPTER 462, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
C. C. Huestis	Assistant engineer	53	$5 00 per day	$265 00	$7 17	$272 17
Dorlon Clark	Leveler	3	4 50 per day	13 50	4 50	18 00
F. J. Lempe	Rodman	53	3 50 per day	185 50	1 56	187 06
H. J. Richardson	Chainman	1	2 50 per day	2 50	....	2 50
Arthur O'Brien	Chainman	15	3 50 per day	52 50	6 25	58 75
						$538 48
INCIDENTAL EXPENSES.						
Office rent					$22 50	
Postage and telegraph					50	
Miscellaneous					3 90	
						26 90
						$565 38

APPENDIX C.

REPORT

OF THE

DIVISION ENGINEER

OF THE

MIDDLE DIVISION

FOR THE

YEAR ENDING SEPTEMBER 30, 1895.

APPENDIX C.

Division Engineer's Office,
Syracuse, *December* 15, 1895.

Hon. Campbell W. Adams, *State Engineer and Surveyor:*

Sir.—Herewith I have the honor to present my annual report, as division engineer of the middle division, New York State canals, for the fiscal year ending September 30th, 1895.

The extent of the middle division remains as reported last year in detail and comprises—

Canal proper	199.80	miles
River improvement	83.05	"
Navigable feeders	16.23	"
Artificial feeders not navigable	29.10	"
Total	328.18	miles

ENGINEER DEPARTMENT.

During the year the middle division has been in charge of the undersigned as division engineer, and George A. Morris as resident engineer, with such assistants as the work devolving upon this Department from time to time required.

The engineering force upon this division has been fully employed during the year in preparing work for letting under a large number of special acts of the Legislature, superintending the construction of work under contracts, preparing monthly, and final estimates; laying out ditches authorized by special laws, where the work has been done by the Superintendent of Public Works, and furnishing plans and bills of materials, and rendering such assistance to the Superintendent of Public Works and section superintendents as the exigencies of each case required.

The following tables are prepared as required by law:

Table No. 1, hereto annexed, shows the names of the engineers duly appointed by the State Engineer and Surveyor, time employed, rate of compensation, and amount paid during the year, with the amount of other miscellaneous expenditures, for ordinary and extraordinary repairs.

Table No. 2 exhibits contracts in force at the close of the fiscal year, together with engineer's estimate of cost of each piece of work and the amount paid thereon.

Table No. 3 exhibits contracts completed and settled during the fiscal year, with the engineer's estimate, and the total cost of each piece of work as returned in final account.

Table No. 4 exhibits water record of Cayuga and Cross lakes and Seneca river, taken tri-annually since 1884, in pursuance of concurrent resolutions of the Senate and Assembly, passed in 1884.

Extraordinary repairs done by contract, under supervision of the Engineer Department during the fiscal year:

ERIE CANAL.

Construction of Two Lift, and One Double Roadway Fixed Bridge over the Erie Canal at Genesee Street, Utica.

Act chapter 560, Laws of 1893.

Hilton Bridge and Construction Co., contractors.

Payments prior to Oct. 1, 1894	$36,610.
Payments during fiscal year	12,310.74
Amount of final account	$48,920.74

After the completion of this work it was found necessary to remove the electrical system adopted for raising the lift bridges and substitute hydraulic power, with air compressor, in place of screws propelled by electricity.

This work was let to Hilton Bridge and Construction Company, under act chapter 170, Laws of 1895, and cost, as per final account rendered, $9,755.15. Since the change the bridge has been in continual operation.

Rebuilding Berme Abutment to Main Street Bridge at Jordan.

Act chapter 297, Laws of 1894.

Edward S. Candee, contractor.

Amount of final account	$5,957.76

This work was necessary in order to maintain travel on the street, as the abutment was tipping into the canal on account of defective foundation. The old iron superstructure was found to be very unsafe, and all the wrought iron links, suspension and sway rods had to be taken out and repaired and new needle beams of steel inserted.

Substructure of Lift Bridge at Geddes Street, Syracuse.

Act chapter 385, Laws of 1894.

Martin & Sullivan, contractors.

Amount of final account	$4,906.90

This work was done before the opening of navigation.

Superstructure of Lift Bridge at Geddes Street, Syracuse.

Act chapter 385, Laws of 1895.

Wrought Iron Bridge Co., contractors.

Amount of final account	$7,634.42

This work was completed in May last, and works perfectly.

Vertical Wall on the Berme Side of the Erie Canal, Between Gilbert and Turner Streets, Utica.

Act chapter 423, Laws of 1894.

James J. Dwyer, contractor.

Amount of final account	$7,958.27

BALDWINSVILLE CANAL.

Stone Dam Across the Seneca River at Baldwinsville.

Act chapter 113, Laws of 1893, and act chapter 130, Laws of 1894.

Hughes Bros.' & Bangs, contractors.

Amount of payments to Oct. 1, 1893	$22,695.00
Amount of payments to Oct. 1, 1894	33,346.95
Amount of final account	$56,041.95

OSWEGO CANAL.

Removing Iron Bridge Superstructure at Geddes Street, Erie Canal, and Re-erecting the same at Sycamore Street, Liverpool.

Act chapter 93, Laws of 1893.

Brummelkamp & Lane, contractors.

Amount of final account	$1,103.37

This superstructure was taken down preparatory to erecting a lift bridge at Geddes street, Syracuse, and thoroughly repaired and re-erected in place of an old wooden bridge which had been unsafe a long time.

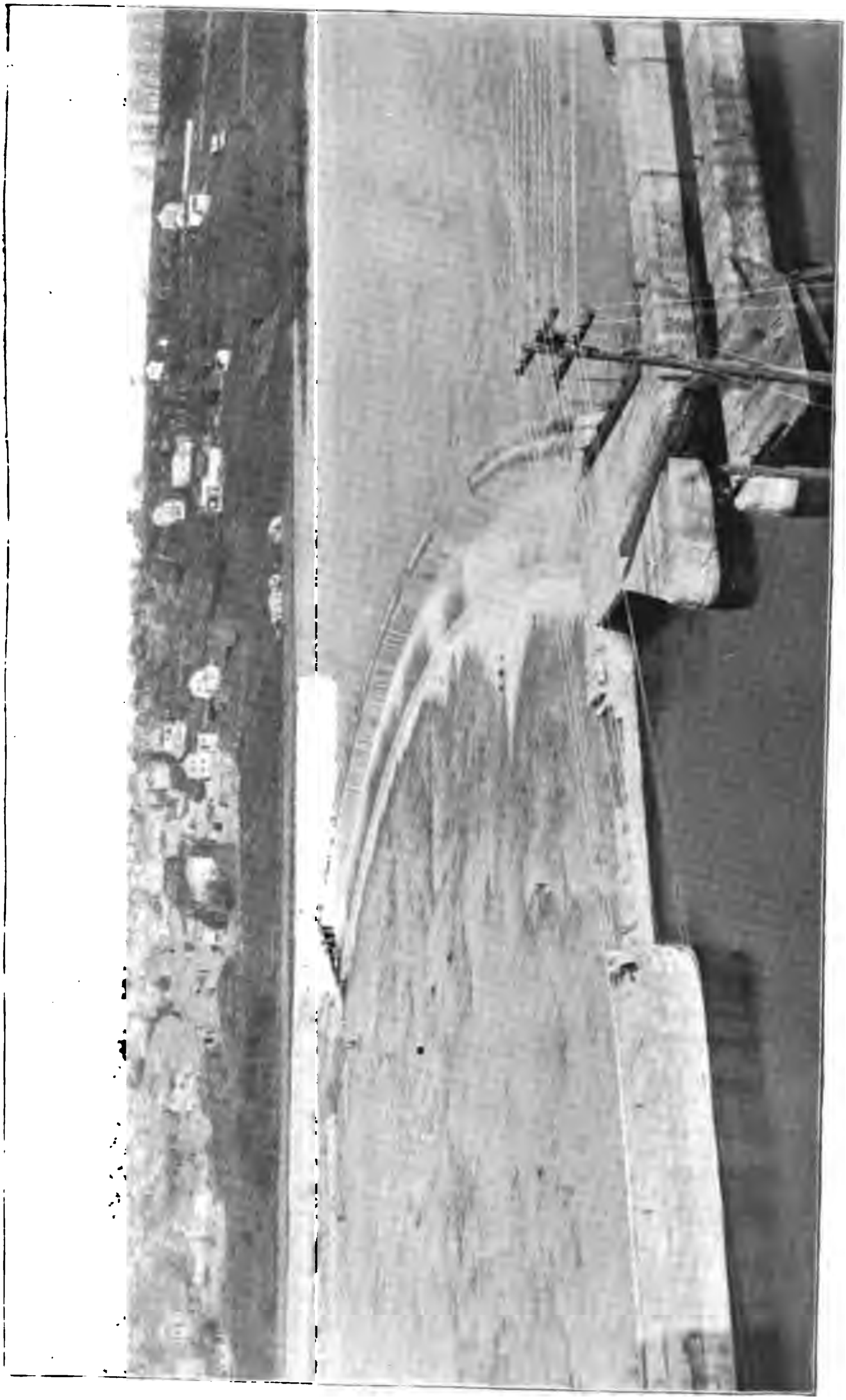
Stone Apron at Oswego Dam.

Act chapter 572, Laws of 1894.

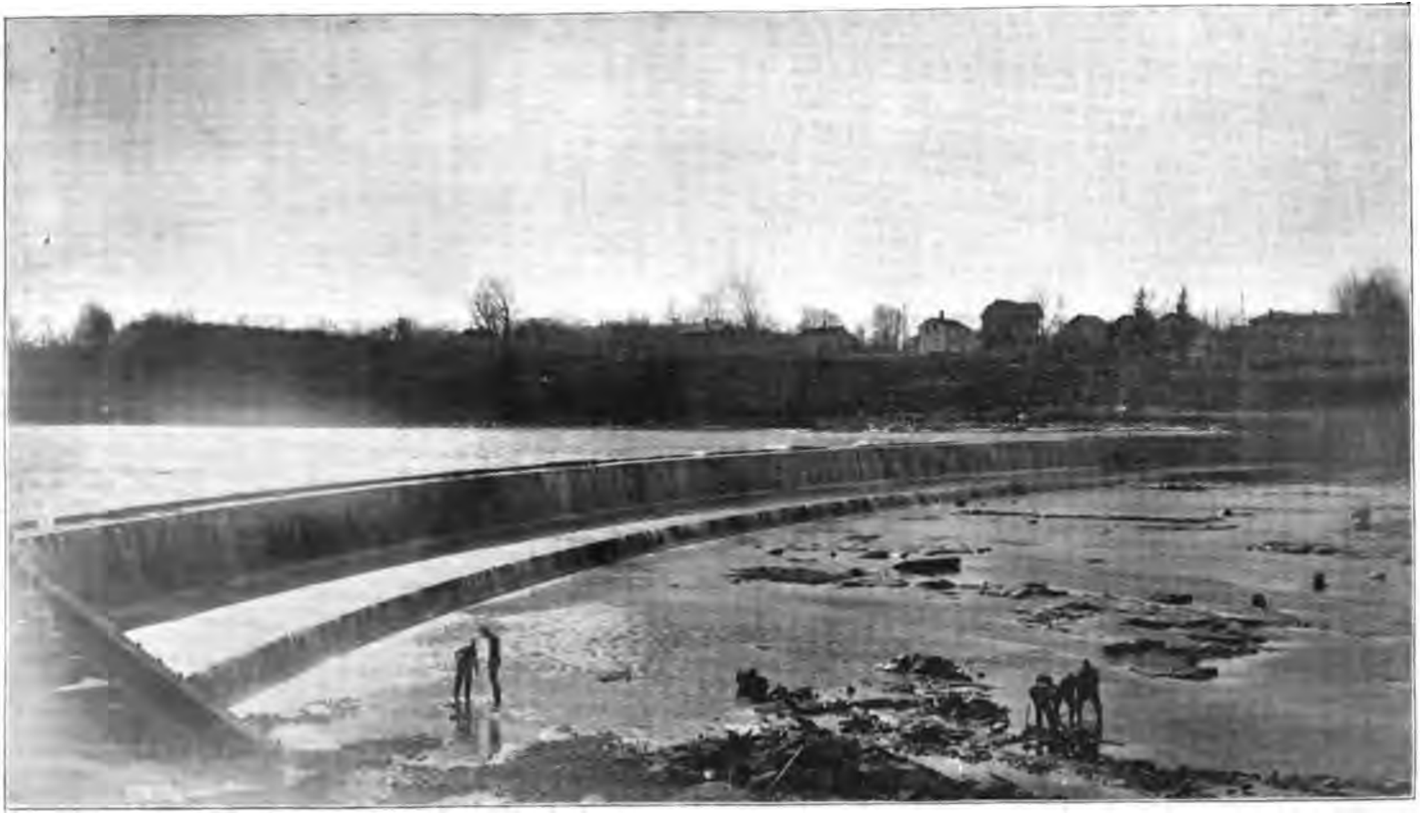
James B. Donnelly, contractor.

Amount of payments to Oct. 1, 1895	$19,907.00

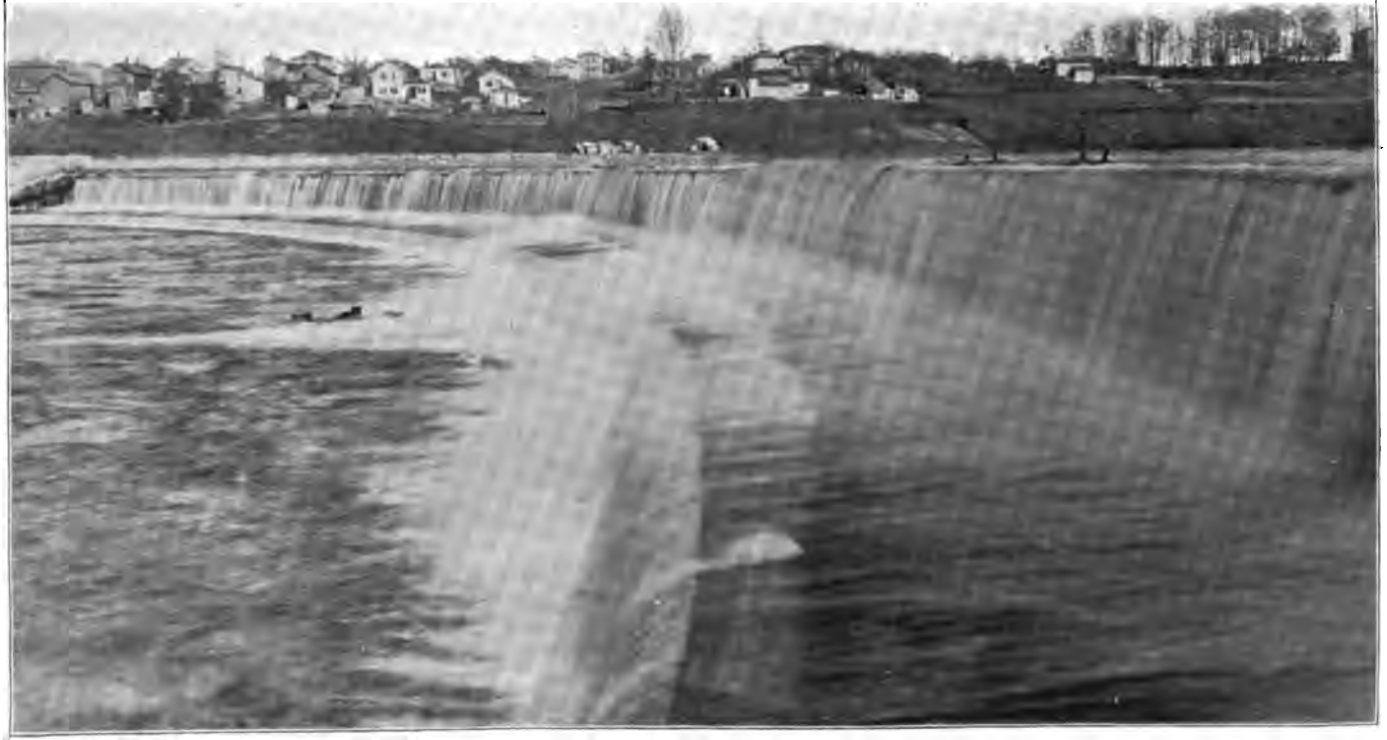
The old timber apron to this dam was entirely carried away,



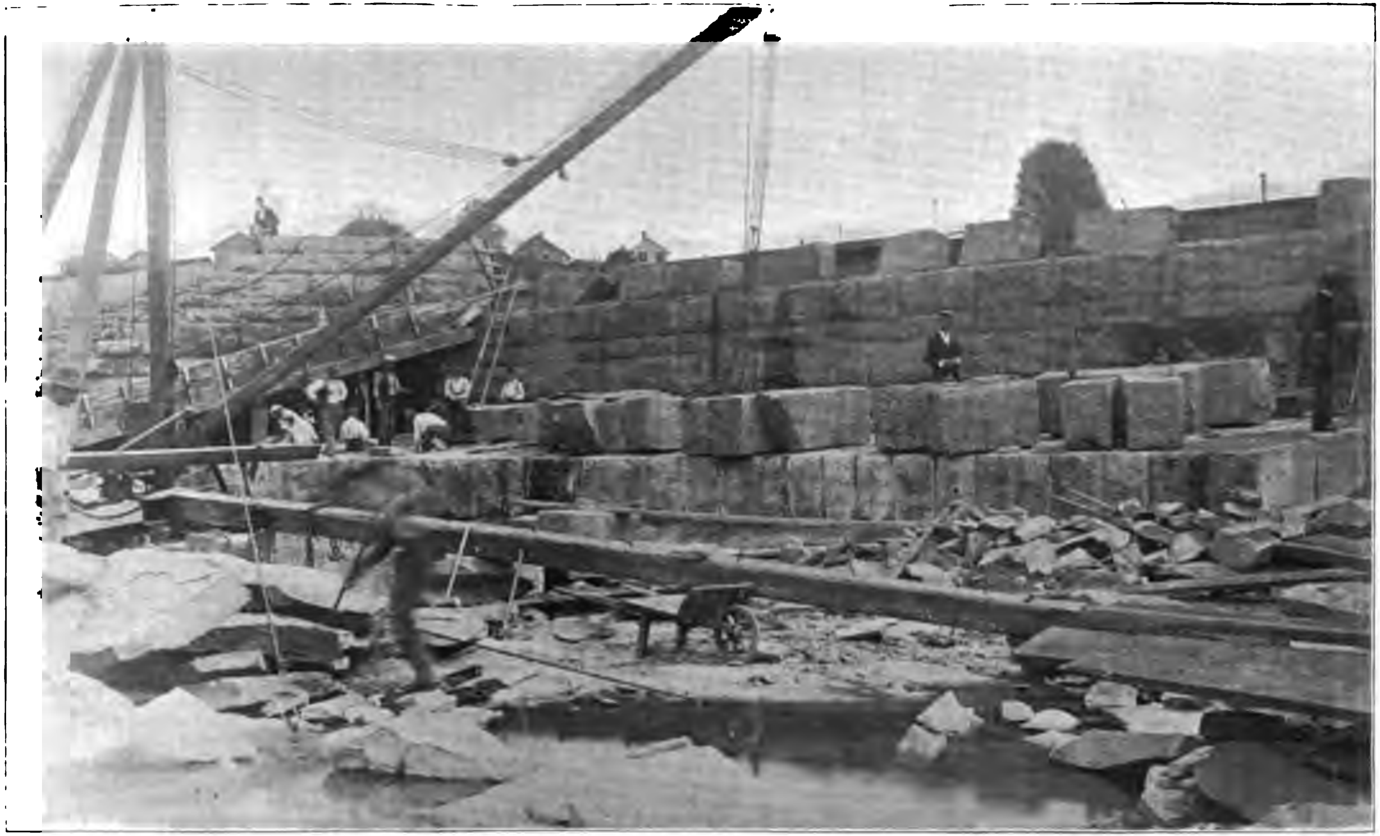
New Stone Apron, Oswego Dam. View from Brewery.



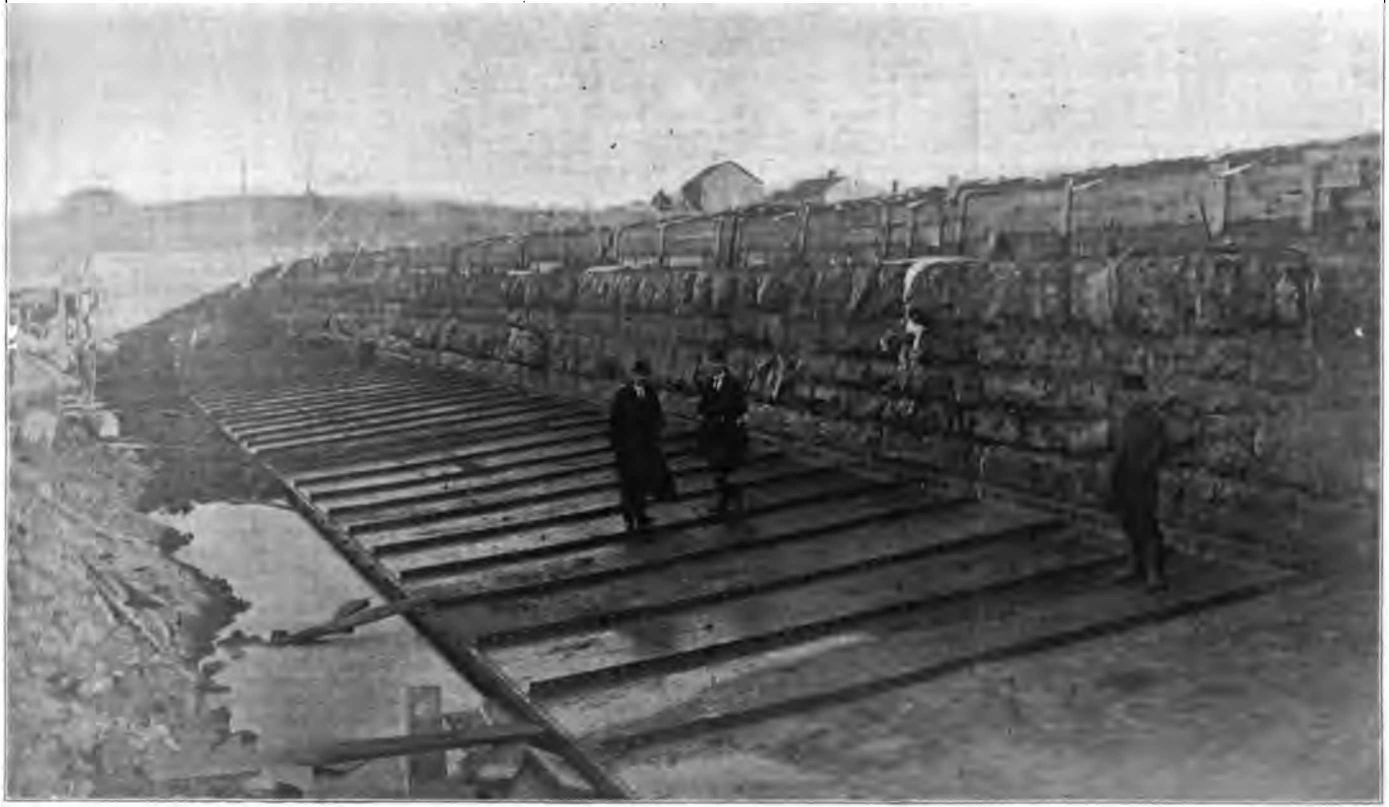
NEW STONE APRON, OSWEGO DAM. VIEW FROM EAST ABUTMENT.



New Stone Apron, Oswego Dam. View from West Abutment.



Stone Apron, Oswego Dam. Under Construction.



Steel Apron. Braddock's Dam, Oswego River.

endangering the dam from undermining. The work is substantially completed, and final account is in preparation.

Steel Apron to Portion of Braddock's Dam, Across the Oswego River.

Act chapter 572, Laws of 1894, and act chapter 512, Laws of 1895.

Hughes Bros'., contractors.

Amount of payments to Oct. 1, 1895	$1,275.00

This work is now in progress, and will be completed by January 1st, 1896. It consists of the construction of a steel plate apron, twenty feet wide, on rubble masonry from the easterly end of the dam to near the center of the river, to replace a timber sloping apron which was carried away several years ago. The bed rock at the location of this dam, as well as at Oswego, is not of a character to withstand the shock of continual flood of water over the dams. The dams are safe only when protected by substantial aprons.

CAYUGA AND SENECA CANAL.

Protecting Berme Bank of Cayuga and Seneca Canal at Geneva.

Act chapter 424, Laws of 1894.

Brayer & Albaugh, contractors.

Amount of final account	$12,491.89

This work consists of a heavy sea wall of quarry stone along the shore of Seneca lake to protect the canal and highway from encroachment.

Protecting Berme Bank of Cayuga and Seneca Canal at Geneva.

Act chapter 142, Laws of 1895.

E. H. Fleming & Co., contractors.

Amount paid to Oct. 1, 1895	$2,465.00

This work is a continuance of sea wall as noted under Brayer & Albaugh, contractors.

When the work under this contract is completed there will be a continuous sea wall along the shore at foot of Seneca lake of about 7,700 feet.

Improving Cayuga and Seneca Canal, at Seneca Falls.

Act chapter 572, Laws of 1894.

George W. Barlow, contractor.

Amount of final account	$7,091.75

This work consists of constructing a division wall in cement on the short level below Lock No. 3 and the mill race; and the excavation of the bottom of the entire level and concreting the bottom thereof to prevent leaks.

Improving Cayuga and Seneca Canal, at Seneca Falls.

Act chapter 512, Laws of 1895.

Willard Johnson, contractor.

Amount paid during fiscal year	$425.00

This work consists of removing an old spillway on berme side of level below Lock No. 4 and substituting an earth bank in place thereof. Also constructing a culvert leading into the short level below Lock No. 3, taking down the towing path bridges, and rebuilding vertical wall on towing path side of canal.

Improving Cayuga and Seneca Canal and Old Bear Race, at Waterloo.

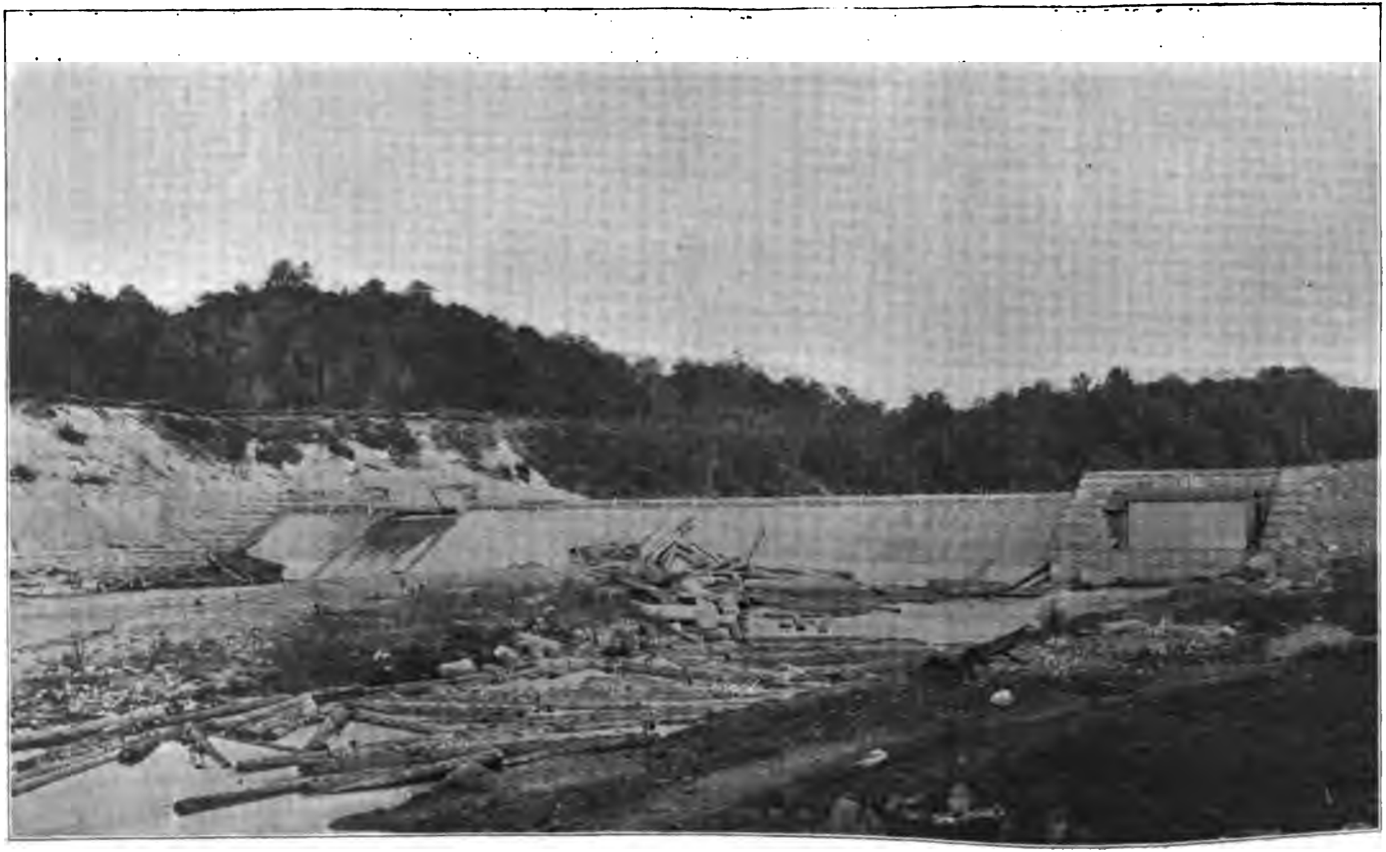
Act chapter 572, Laws of 1894, and act chapter 512, Laws of 1895.

G. W. Barlow, contractor.

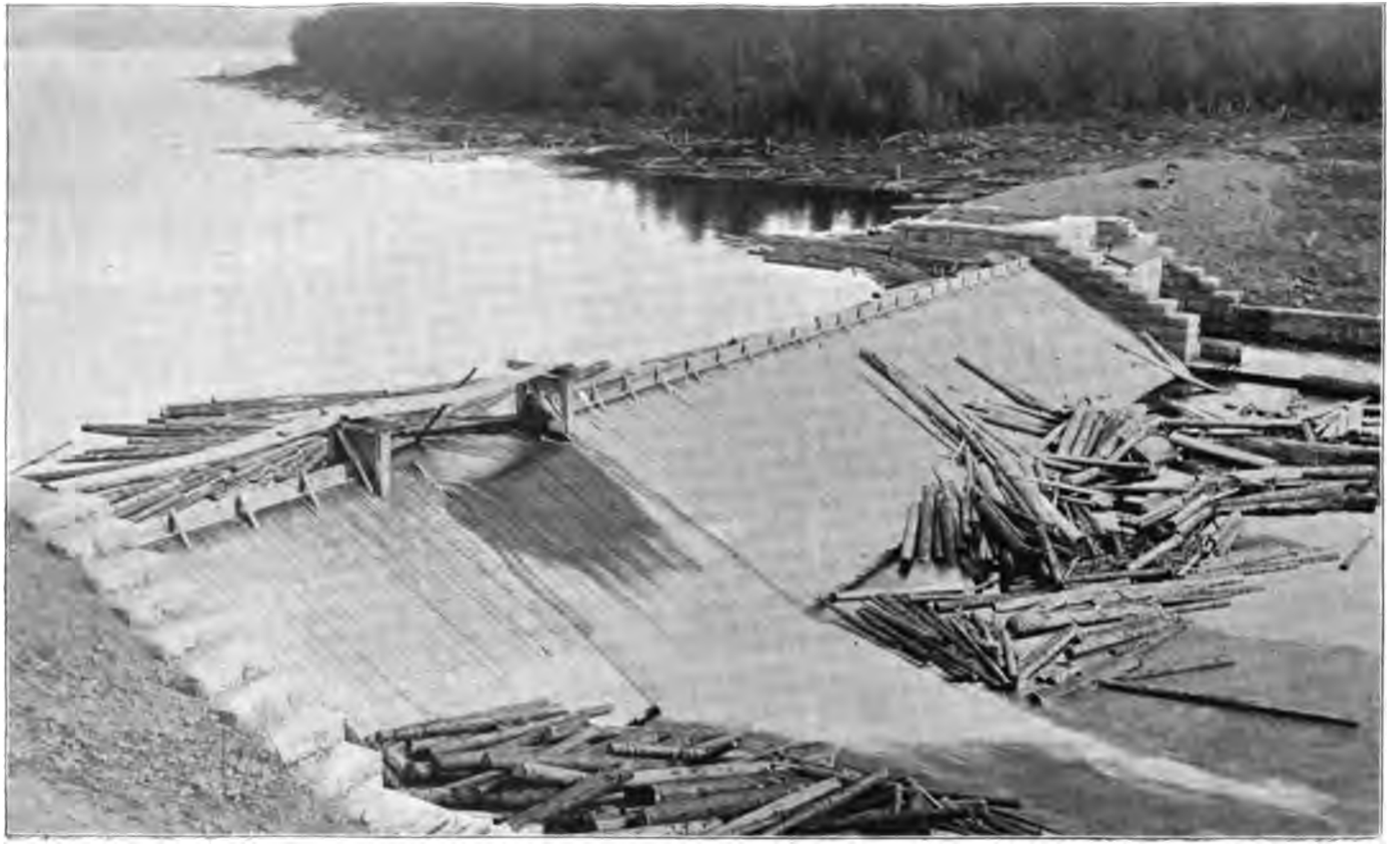
Amount paid during fiscal year	$221.00

This work consists of excavating the bottom of Old Bear Race thirty feet wide on bottom to two and one-half feet above canal bottom; and the construction of a road bridge across the same.

This work is now in progress.



New Dam, Black River Reservoir. Alder Creek.



New Dam, Black River Reservoir, at Alder Creek.

Improving Cayuga and Seneca Canal and Seneca Lake Outlet.

Act chapter 308, Laws of 1895.

E. H. Fleming & Co., contractors.

Amount of payments to Oct. 1, 1895..................	$442.00

This work consists in dredging the outlet, constructing stone pier or breakwater at outlet, and docking on Geneva level.

BLACK RIVER CANAL.

Rebuilding Locks Nos. 18, 28 and 37.

Act chapter 572, Laws of 1894.

Lock No. 18—A. Van Wagner & Co., contractors.	
Amount of final account..........................	$17,502.90
Lock No. 28—Mulcahy & Co., contractors.	
Amount of final account..........................	$17,201.59
Lock No. 37—Mulcahy & Co., contractors.	
Amount of final account..........................	$14,619.36

These locks are built of dressed gray limestone—ninety feet between quoins and sixteen feet wide—in a most substantial and durable manner.

Rebuilding Portion of Combined Locks, Nos. 39, 40, 41 42 *and* 43.

Act chapter 1030, Laws of 1895.

Dodge & McGregor, contractors.

No payment has yet been made on account of this work.

With the appropriation of $45,000 about one-half of these combined locks will be rebuilt the coming winter of dressed gray limestone.

The locks upon this canal are in very bad condition, and it is certain that unless the sum annually set apart for rebuilding those in worse condition is increased materially, the restoration will not keep pace with the steady decay.

MISCELLANEOUS.

Sluice in North Branch Reservoir.

Act chapter 726, Laws of 1893.

A. C. Hall, contractor.

Amount of final account	$6,175.69

This work consists of constructing a timber log sluice and chute in the spillway, and paving with stone the spillway at North lake reservoir, in order to permit the passing of logs from reservoir into the river below dam.

Road and Spillway at North Branch Reservoir.

Act chapter 148, Laws of 1895.

Michael Bennett, contractor.

Amount of payments to Oct. 1, 1895	$1,411.00

This work consists in lengthening the spillway to insure safety to the reservoir when full. The very large water shed surrounding this reservoir requires a longer spillway than was provided under former contract of A. C. Hall.

The old road bridge below the spillway was condemned as unsafe, and in order to put a new bridge where it would not be liable to being carried away in extreme freshets, it was decided to locate it above the log chute stone abutments and pier will be constructed with wooden bridges spaning the stream. The road will be changed to conform with the new location of bridge.

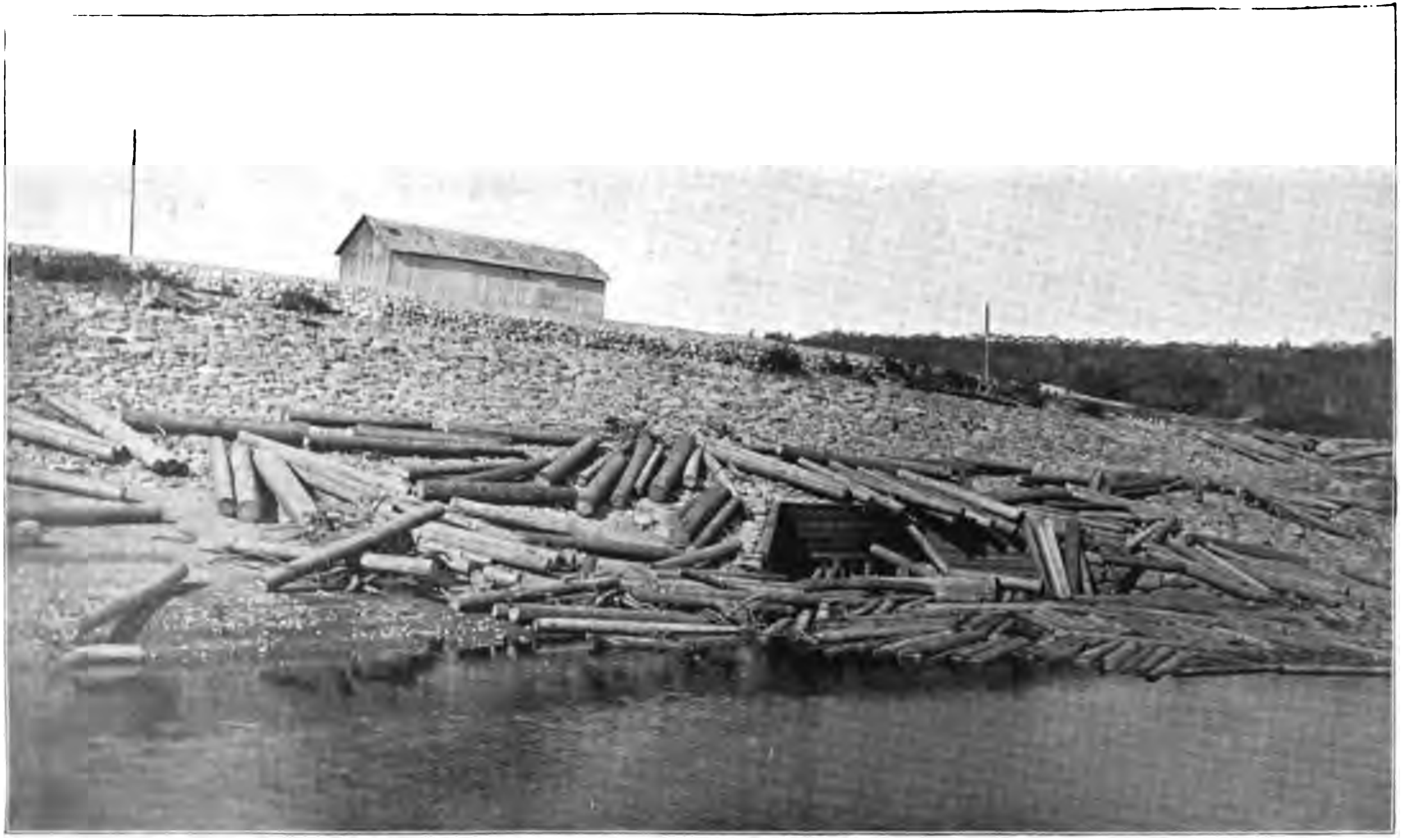
Inserting Discharge Pipes at North Lake Reservoir.

Act chapter 148, Laws of 1895.

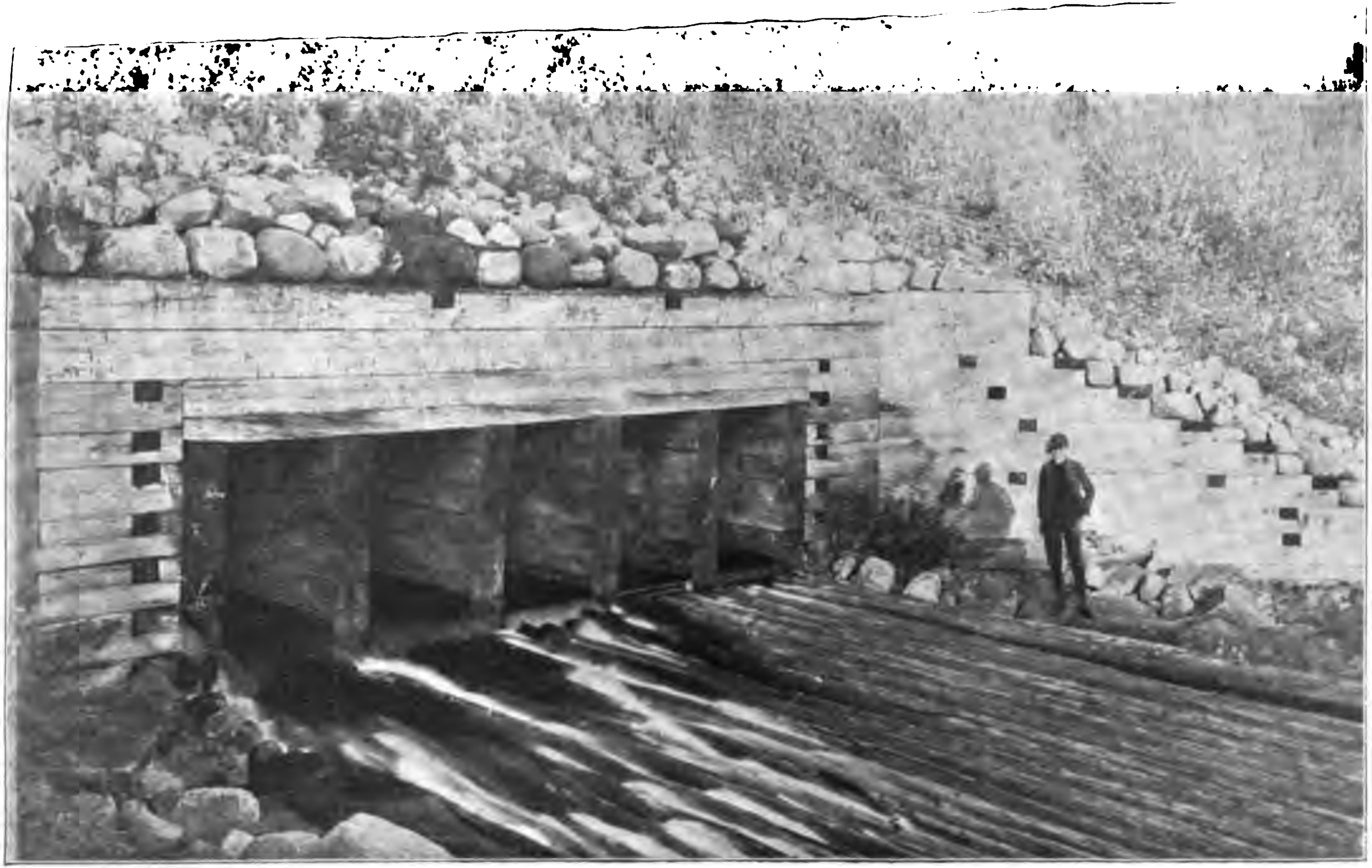
John H. Nelson, contractor.

No payments have been made on account of this contract.

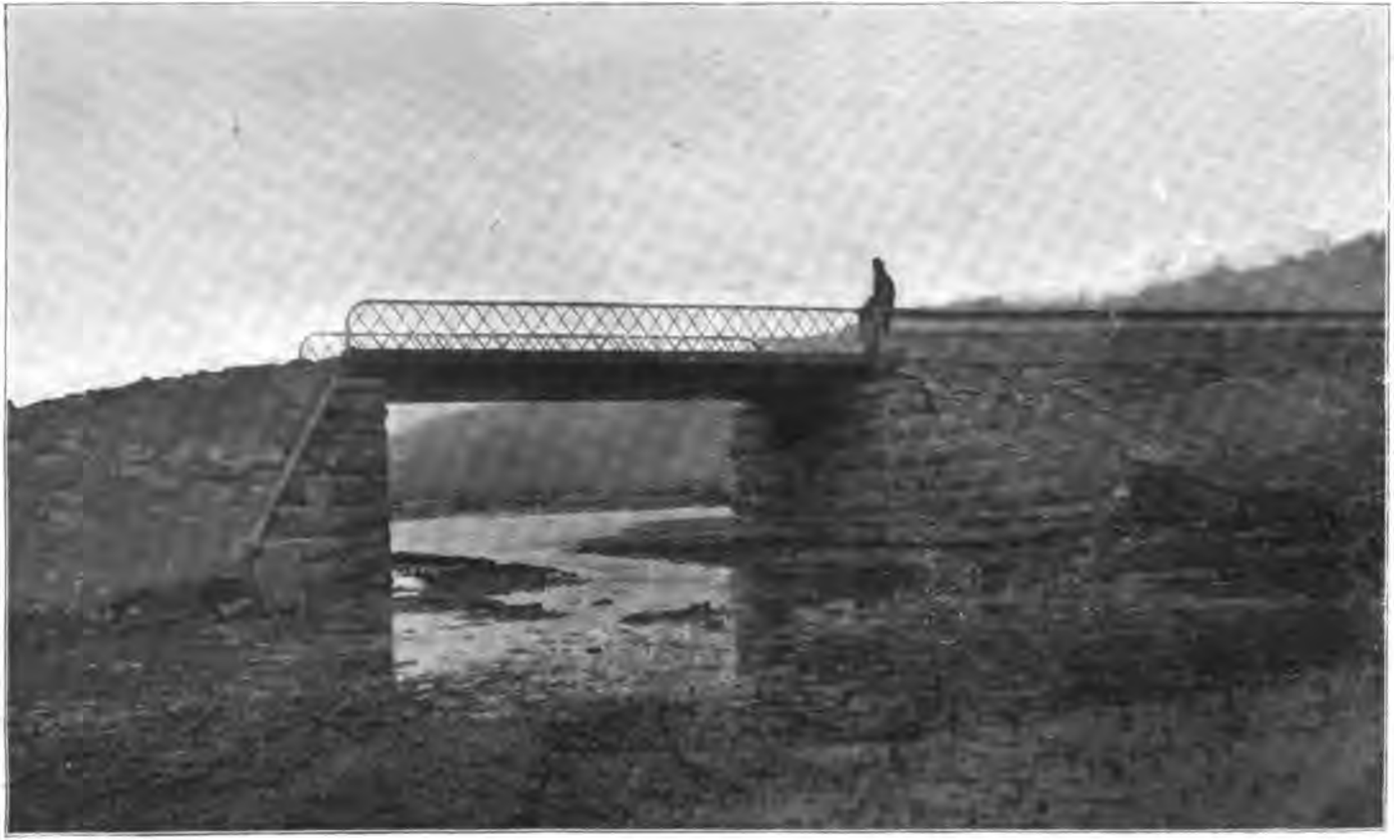
The old timber culverts and gates through the reservoir bank are so badly decayed that it is deemed wise to substitute four cast iron pipes of thirty inches in diameter from present head gates to point of discharge.



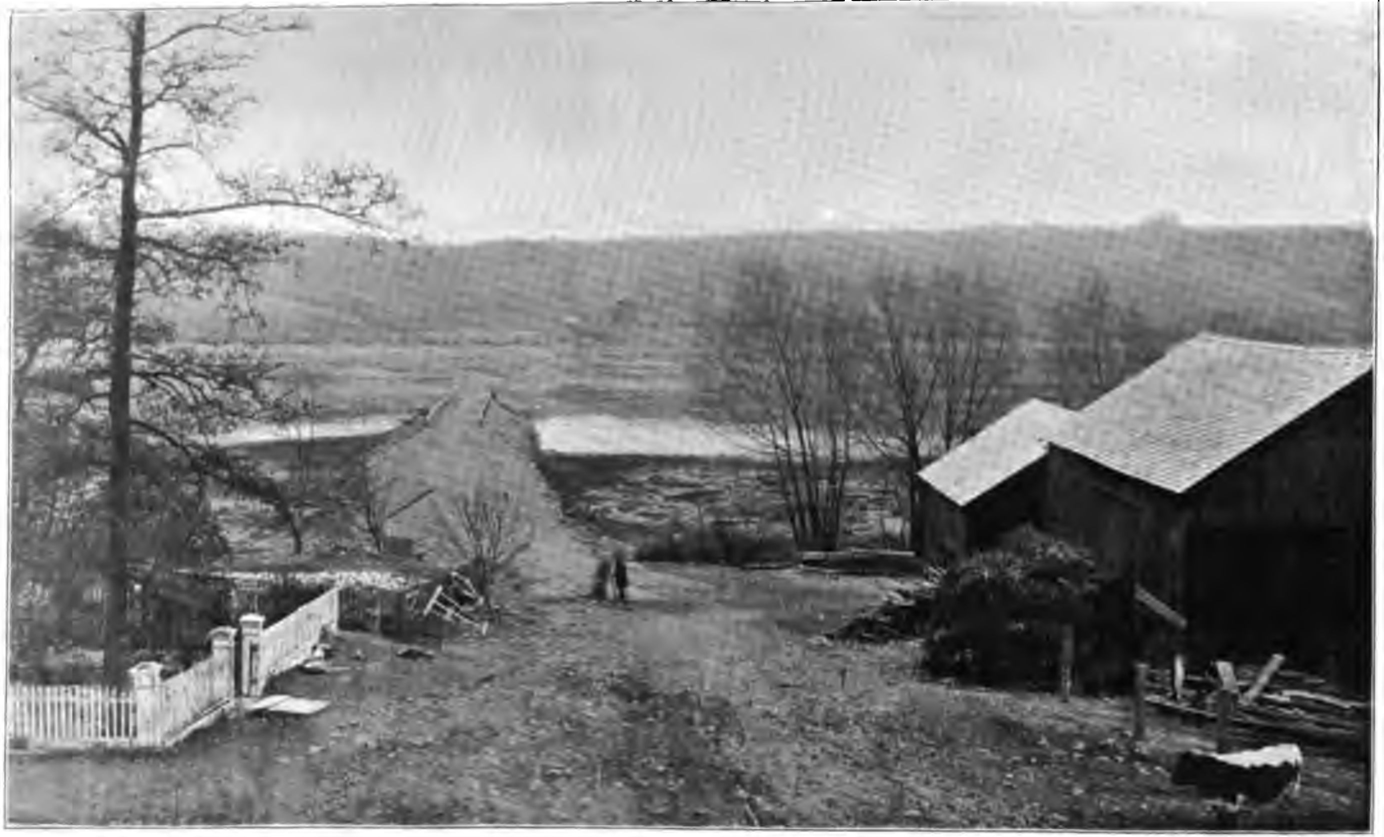
Present Dam, North Branch Reservoir. View from Above.



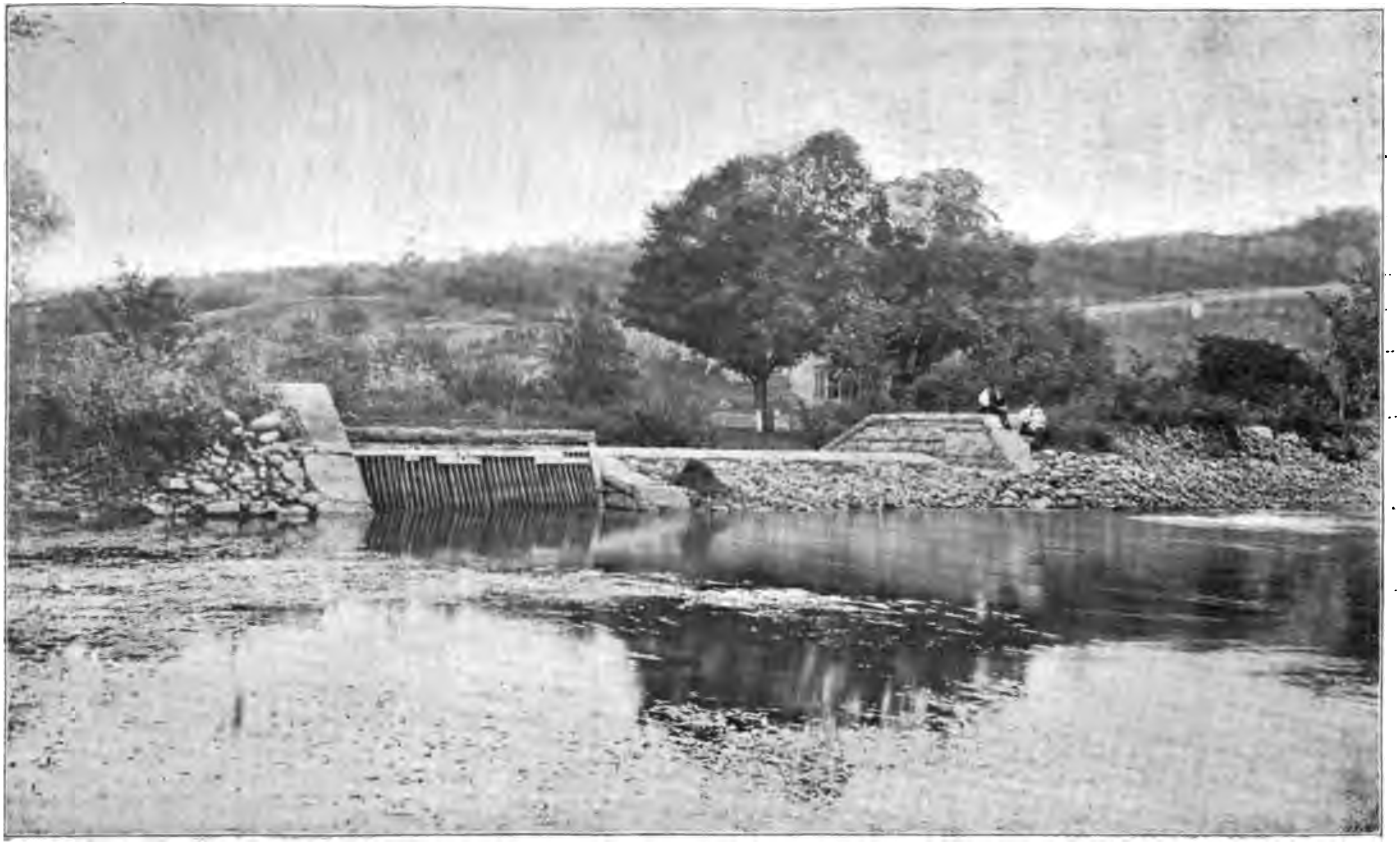
North Branch Reservoir View from Below.



Otisco Lake Road. View of Bridge Over Inlet.



Otisco Lake Road. Showing Work Done and Work to be Done.



STATE DAM AT FOOT OF OTISCO LAKE RESERVOIR.

I recommend that the plan be changed extending the pipe entirely through the embankment. The additional cost will be about $9,000 if done under the present contract; then the reservoir will be entirely safe, which cannot be said as long as any portion of the old timber culvert remains.

Removing Bars and Dredging Channel at Cayuga Inlet.

Act chapter 656, Laws of 1894.

Hingston & Woods, contractors.

Amount of final account	$3,802.14

This work is completed, and permits boats to pass from Cayuga lake to Ithaca.

Repairs of Madison and Lebanon Feeders.

Act chapter 570, Laws of 1894.

Edward S. Candee, contractor.

Amount of final account	$8,837.79

This work consisted of cleaning out Madison brook feeder for its entire length, constructing three highway bridges of stone and steel, replacing waste weir and receiver. On Lebanon feeder several structures were rebuilt, and break in feeder repaired.

On the summit level of the old Chenango canal, which is used as a feeder for the Erie canal, bars had formed that prevented flow of water, all of which were removed under this contract.

Otisco Lake Inlet Bridge and Approaches.

Act chapter 497, Laws of 1895.

Edward S. Candee, contractor.

Amount of payments to Oct. 1, 1895	$1,105.00

This work consists of building a bridge and approaches across the low ground at the head of Otisco lake in line of old road, which is overflowed about ten feet when the lake is full to top of dam.

The work which will be done under this contract will be of no benefit, nor can it be used until the road is raised entirely across the lake; to do this a further appropriation of $23,000 will be required.

Before Otisco lake was appropriated for a reservoir, the highway across the head of the lake was in use, but since the construction of the dam at the outlet, thereby raising the surface of the lake, it has been impassable; should the road be raised above high water the travel thereon will be saved some five miles, in going round the head of the lake.

In making an initiatory appropriation for the work it is assumed that the Legislature concede the liability of the State to restore the highway to its former usefulness. Upon this theory I recommend a further appropriation to complete the work.

State Ditch at Cowaselon Swamp.

Act chapter 366, Laws of 1895.

E. S. Gay, contractor.

Amount of payments to October 1, 1895............ $1,360.00

This work consists of enlarging and lowering the ditch between Canastota and Lake Oneida 10 8-10 miles. The appropriation, $30,000.00, will undoubtedly complete the work upon the plan adopted.

Repairs of Owasco Lake Outlet.

Act chapter 99, Laws of 1895.

John J. Hallcok, contractor.

Amount of payments to Oct. 1, 1895................ $442.00

This work consists of new construction on top of State dam on outlet of Owasco Lake, and construction of pile breakwater with rip-rap protection at the lower end of lake at its entrance to the outlet.

There is further work which should be done in dredging out the outlet, and constructing steel headgates and frame at the State dam. An appropriation of $8,000.00 could be expended to advantage, which would enable the drawing a large additional amount of water from the lake for use of the Erie canal, and at the same time benefit the prison and mills at Auburn.

SUMMARY OF WORK DONE UNDER CONTRACT DURING THE FISCAL YEAR.

Two lift and one fixed bridge over Erie canal at Utica	$12,310 74
Changing lifting power of lift bridge at Utica, from electricity to compressed air..................	9,755 15
Rebuilding Berme abutment of Main street bridge at Jordan, and repair superstructure...........	5,957 76
Substructure of lift bridge at Geddes St., Syracuse	4,906 90
Superstructure of lift bridge at Geddes St., Syracuse	7,634 42
Vertical wall between Hubbell and Turner streets, Utica..	7,958 27
Stone dam at Baldwinsville.....................	33,346 95
Removing iron superstructure at Geddes street, and re-erecting the same at Sycamore street, Liverpool	1,103 37
Stone apron at Oswego dam......................	19,907 00
Protecting Berme bank of Cayuga and Seneca canal at Geneva..................................	12,491 89
Protecting Berme bank, Cayuga and Seneca canal, at Geneva..................................	2,465 00
Improving Cayuga and Seneca canal at Seneca Falls	7,091 75
Improving Cayuga and Seneca canal at Seneca Falls	425 00
Improving Cayuga and Seneca canal and Old Bear Race at Waterloo............................	221 00
Improving Cayuga and Seneca canal and Seneca lake outlet..................................	442 00
Rebuilding locks 18, 28, and 37, Black River canal:	
Lock No. "18"................................	17,502 90
Lock No. "28"................................	17,201 59
Lock No. "37"................................	14,619 36
Sluice in North Branch reservoir................	6,175 69

Road and spillway at North Branch reservoir.....	$1,411 00
Removing bars and dredging channel of Cayuga inlet, at Ithaca..............................	3,802 14
Repairs on Madison brook and Lebanon feeders....	8,837 79
Otisco lake inlet bridge and approaches...........	1,105 00
State ditch at Cowaselon swamp.................	1,360 00
Repairs of Owasco lake outlet....................	442 00
Total payments.	$198,474 67

EXTRAORDINARY REPAIRS DONE BY THE SUPERINTENDENT OF PUBLIC WORKS, UNDER SUPERVISION OF THIS DEPARTMENT, DURING THE FISCAL YEAR.

In April last, just before opening of navigation, a break occurred at Bloody Brook culvert, near Liverpool, on the Oswego canal, which necessitated taking up two-thirds of the culvert, concreting the foundation, rebuilding the structure and embankments over the same; delaying the opening of the Oswego canal four days.

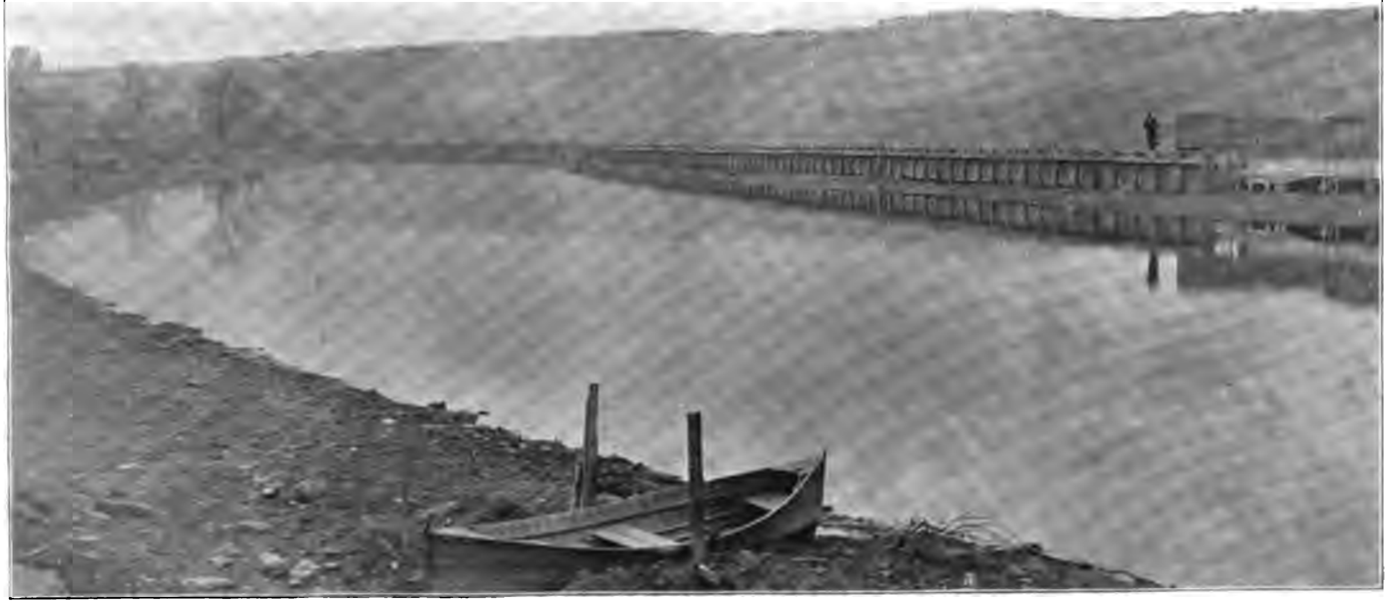
This work was made very expensive in order to protect it against the very high water in the lake, which rendered heavy coffer dams necessary entirely around the pit, and continually pumping until the work was completed.

From long neglect, the culvert had become entirely filled with silt, so that no water could pass through any of the five spaces, thereby damaging the stream until it broke into the canal, undermining the culvert to a depth of about four feet.

Since the repairs to this culvert, the land above has been cultivated where before it had been inundated for some years, creating claims for damage on the part of the property owners.

There are many diving culverts on this division, either full or nearly so, which should be cleaned out and kept clean, or the experience of Bloody Brook may be repeated.

As recommended by me in my last annual report, the old dilapi-



VIEW OF PILING OUTLET OF LAKE KEUKA.

dated waste-weir, east of Higginsville, has been removed and a substantial earth embankment substituted, and the adjoining culvert cleaned out.

A new wooden trunk was put in Camillus aqueduct before the opening of navigation. I advise that no more timber be used in aqueduct trunks or in waste weirs, as steel construction will cost but little, if any, more than good timber, and when built of steel and iron, reconstruction every few years will not be necessary.

At High dam, on Oswego river, a dangerous condition arose during the season from the lining above the dam being washed away, allowing the water of the river to pass through the filling above, and the crib foundation under the stone dam; by prompt action necessary repairs were made to insure the safety of the dam for the present, but further precaution should be taken by adding to the lining above the dam, and restoring all that may wash away. As long as the filling above is tight, the dam will be safe.

There was a break in the division wall between the canal below the upper lock at Oswego, and the Hydraulic canal over the culvert; this was temporarily repaired without causing much delay to navigation.

Before the opening of navigation in the spring the masonry in overflow walls of Teffts and Ballou's waste weirs were taken up and relaid in Portland cement mortar.

The trunk of Oriskany creek aqueduct was lined on bottom before opening of navigation, to prevent leakage.

NEEDED ORDINARY REPAIRS.

While it has been customary for the Division Engineer in his annual report to specifically suggest repairs that are needed upon the division, that branch of the service more properly belongs to the Department of the Superintendent of Public Works, and I have not thought it advisable to recapitulate many of the suggestions and recommendations in my report of last year, always being ready to examine and report upon any question relating to the repairs and maintenance of any portion of the canals included in the middle division that may be desired by officers in charge.

Questions are constantly arising that require examination, measurement, plans, specifications and superintendence of this department, and in all cases such service is promptly rendered, and I am happy to say that the most cordial intimacy and good feeling exists not only in this department but with every other department of the public service.

All of which is respectfully submitted,

W. H. H. GERE,
Division Engineer.

SYRACUSE, N. Y., *November* 27, 1895.

W. H. H. GERE, *Division Engineer*, *Syracuse*, *N. Y.*:

Dear Sir.—Chapter 851, Laws of 1895, appropriated $2,000 for cleaning the State ditch, and ditches tributary thereto, on original lots Nos. 45, 46, 54 and 55 in the town of Manlius, Onondaga county. The following ditches have been cleaned by day work, under the personal supervision of Clinton Snook, Section Superintendent of section No. "6," Erie canal.

First.— Ditch No. "1" begins at the Chenango Valley Railroad crossing of the Erie canal, and extends in an easterly direction along the rear slope of the tow path for 800 feet; and thence in a northerly direction 3,400 feet to Limestone creek. This ditch was cleaned out to a width of four feet on bottom, with a minimum grade of 0.2 feet per 100, Twenty-five hundred cubic yards of material were removed.

Second.— Ditch No. "2." This ditch takes the canal leakage from Manlius Center road bridge to a point 2,000 feet east, and drains into ditch No. "1" at a point 1,200 feet from its lower end; the total length of ditch cleaned is 2,800 feet, with a minimum grade of 0.2 of a foot per 100. Seventeen hundred cubic yards of material were removed.

Third.— Ditch No. "3." This ditch has a total length of 3,000 feet, with a minimum grade of 0.4 of a foot per 100; it takes the canal leakage from the east end of ditch No. "2" for a distance of 1,000 feet, and drains into ditch No. "2" at the Manlius road. Twelve hundred cubic yards of material were removed.

In addition to that, part of the open ditch running along the Manlius road was replaced by an eighteen inch tile drain.

Fourth.—Ditch No. "4." This ditch was constructed by the State in 1858, extending from the Erie canal through the Collins swamp to Limestone creek, a distance of 7,200 feet, with a minimum grade of 0.04 per 100 feet; this ditch has been thoroughly cleaned out, and all trees and brush removed from the channel; from the south end side ditches have been opened along the rear of the tow path to carry off the leakage from the canal; the westerly side ditch is 2,000 feet long, while the easterly side ditch is 2,800 feet long; an eighteen-inch tile drain has been used to carry the east ditch under the Sutter road. Eight thousand cubic yards of material have been removed.

The work of cleaning these ditches has been very thorough, the center grade stakes have been closely followed, and the bottom width is in no case less than three feet, a total of 13,400 cubic yards of earth have been removed, and one-half a mile of grubbing and clearing through the Collins swamp has been completed in a thorough and workmanlike manner.

Before closing this report, I desire to express my appreciation of the services of Mr. Clinton Snook, who has had personal charge of the work. I am convinced that the excellent showing made on this work is mainly due to his energetic management. In my opinion, this work has been done at least twenty per cent. cheaper than it could have been done by contract, and I have insisted upon the Superintendent doing the same thorough work, that I should have demanded from a private contractor; each man on this work has been compelled to give a full day's work for a full day's pay; as a result the farmers and other parties, whose property has been benefited by the cleaning of these ditches are unanimous in saying that the result obtained from the expenditure of this small appropriation have far exceeded their expectations.

I state this the more clearly as my experience in the past has been that special appropriations when expended directly by the Superintendent, and not by contract, have been used more for political effect than to accomplish the work needed.

As I have represented the Engineering Department on all of the pieces of work done this year on our division, directly by the Superintendent, instead of by contract, as is usual, I wish to state that the work has been done in as thorough a manner, and more economically for the State than if it had been let by contract.

If the character of the work done by the Superintendent in the future can be kept at the high standard maintained this year, I would recommend that the smaller special appropriations, requiring only unskilled labor, be expended directly by the Superintendent, instead of by contract, as I am convinced that it would be more economical for the State.

Respectfully yours,

AMBROSE C. DRISCOLL,

Asst. Engineer in Charge.

PRESENT CONDITION OF LOCKS ON THE OSWEGO CANAL, NOV. 26, 1895.

NO. OF LOCK.	LEVELS.		Lift.	Date of Lengthening.	Cost.	Location.
	Upper.	Lower.				
			feet.			
Lift Lock No. 1...	Canal	Canal	11.0	....	....	Syracuse.
" " 2....	Canal	Canal	11.0	....	....	"
" " 3....	Canal	Canal	10.5	....	....	"
" " 4....	Canal	North Side Cut	9.68	....	....	"
" " 5....	Canal	Seneca River	9.68	1886-1887	$26,212.44	Mud Lock.
Guard Lock No. 1..	Oswego River	Canal	....	1886-1887	12 880.54	Phoenix.
Lift Lock No. 6...	Canal	Canal	7.0	1886-1887	17,910.36	Hinmansville.
Guard Lock No. 2..	Canal	Canal	....	....	....	....
Lift Lock No. 7....	Canal	Oswego River	5.87	1887-1888	21,066.68	....
Guard Lock No. 3..	Oswego River	Canal	....	1888-1889	19,970.00	Fulton.
Lift Lock No. 8....	Canal	Canal	11.25	1890-1891	34,493.39	"
" " 9....	Canal	Canal	7.25	1889-1890	24,374.95	"
" " 10....	Canal	Canal	9.00	1889-1890	24,077.07	"
" " 11....	Canal	Oswego River	11.67	1888-1889	29,039 32	....
Guard Lock No. 4..	Oswego River	Canal	....	1887-1888	13,696.16	Battle Island.
Lift Lock No. 12..	Canal	Oswego River	11.25	1890-1891	38,933.16	....
" " 13...	Oswego River	Canal	5.65	....	....	Minetto
" " 14...	Canal	Oswego River	9.25	....	....	....
" " 15...	Oswego River	Canal	5.75	....	....	High Dam.
" " 16...	Canal	Oswego River	8.69	....	....	Oswego.
Guard Lock No. 5..	Oswego River	Canal	....	....	....	"
Lift Lock No. 17...	Canal	Canal	10 50	....	....	"
" " 18...	Canal	Oswego Harbor	from 9.25 to 13.33	....	....	"

TABLE NO. 1.

STATEMENT Showing the Names, Rank and Compensation of Engineer Employed on the Middle Division of the New York State Canals, together with the Incidental Expenses for the Fiscal Year ending September 30, 1895.

ORDINARY REPAIRS—ERIE CANAL.

CHAPTER 297, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$624 65	$44 17	$668 82
Geo. A. Morris	Resident engineer	....	2,000 00 per year	504 10	115 71	619 81
A. C. Driscoll	Ass't engineer in charge	35	6 00 per day	210 00	40 79	250 79
W. W. Jeffers	Assistant engineer	4	5 00 per day	20 00	6 71	26 71
Edwin Styring	Leveler	9	4 50 per day	40 50	....	40 50
Paul L. Schultze	Leveler	76	4 50 per day	342 00	20 64	362 64
Theo. A. Hendrickson	Leveler	35	4 50 per day	157 50	7 77	165 27
George C. Diehl	Leveler	4	4 50 per day	18 00	16 11	34 11
E. A. Lamb	Rodman	3	3 50 per day	10 50	....	10 50
Fred J. Wagner	Rodman	4	3 50 per day	14 00	7 79	21 79
C. K. Munroe	Chainman	178	4 00 per day	712 00	....	712 00
E. J. Berry	Chainman	77	3 50 per day	269 50	75 86	345 36
Fred. J. Wagner	Chainman	22	2 50 per day	55 00	9 08	64 08
J. J. Schmid	Chainman	73	2 50 per day	182 50	34 56	217 06
Wm. Rowlands	Chainman	44	2 50 per day	110 00	3 91	113 91
L. Kavanagh	Chainman	50	2 50 per day	125 00	38 90	163 90
John Schimmel	Chainman	63	2 50 per day	157 50	....	157 50
James Thomson	Chainman	11	2 50 per day	27 50	5 80	33 30
C. Hurlbut	Chainman	20	2 50 per day	50 00	29 34	79 34
Jay Capron	Chainman	9	5 00 per day	45 00	....	45 00
D. E. Whitford	Chainman	18	5 00 per day	90 00	20 24	110 24
C. A. Cockroft	Chainman	3	4 50 per day	13 50	4 96	18 46
INCIDENTAL EXPENSES.						$4,261 09
Stationery					$207 98	
Office rent					14 00	
Fuel					58 50	
Light					10 20	
Postage and telegraph					145 27	
Miscellaneous					752 95	
						1,188 90
						$5,449 99

ORDINARY REPAIRS—OSWEGO CANAL.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$341 92	$3 40	$345 32
Geo. A. Morris	Resident engineer	....	2,000 00 per year	54 78	18 04	72 82
A C Driscoll	Ass't engineer in charge	5	6 00 per day	30 00	6 35	36 35
Fred. J. Wagner	Rodman	4	3 50 per day	14 00	2 60	16 60
C. K. Munroe	Chainman	20	4 00 per day	80 00	....	80 00
E. J. Berry	Chainman	3	3 50 per day	10 50	4 83	15 33
J. J. Schmid	Chainman	4	2 50 per day	10 00	4 93	14 93
C. Hurlbut	Chainman	6	2 50 por day	15 00	9 09	24 09
D. E. Whitford	Chainman	5	5 00 per day	25 00	2 40	27 40
						$632 84
INCIDENTAL EXPENSES.						
Postage and telegraph					$6 00	
Miscellaneous					2 00	
						8 00
						$640 84

TABLE NO. 1.

STATEMENT Showing the Names, Rank and Compensation of Engineer Employed on the Middle Division of the New York State Canals, together with the Incidental Expenses for the Fiscal Year ending September 30, 1895.

ORDINARY REPAIRS—ERIE CANAL.

CHAPTER 297, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$624 65	$44 17	$668 82
Geo. A. Morris	Resident engineer	....	2,000 00 per year	504 10	115 71	619 81
A. C. Driscoll	Ass't engineer in charge	35	6 00 per day	210 00	40 79	250 79
W. W. Jeffers	Assistant engineer	4	5 00 per day	20 00	6 71	26 71
Edwin Styring	Leveler	9	4 50 per day	40 50	....	40 50
Paul L. Schultze	Leveler	76	4 50 per day	342 00	20 64	362 64
Theo. A. Hendrickson	Leveler	35	4 50 per day	157 50	7 77	165 27
George C. Diehl	Leveler	4	4 50 per day	18 00	16 11	34 11
E. A. Lamb	Rodman	3	3 50 per day	10 50	....	10 50
Fred J. Wagner	Rodman	4	3 50 per day	14 00	7 79	21 79
C. K. Munroe	Chainman	178	4 00 per day	712 00	....	712 00
E. J. Berry	Chainman	77	3 50 per day	269 50	75 86	345 36
Fred. J. Wagner	Chainman	22	2 50 per day	55 00	9 08	64 08
J. J. Schmid	Chainman	73	2 50 per day	182 50	34 56	217 06
Wm. Rowlands	Chainman	44	2 50 per day	110 00	3 91	113 91
L. Kavanagh	Chainman	50	2 50 per day	125 00	38 90	163 90
John Schimmel	Chainman	63	2 50 per day	157 50	....	157 50
James Thomson	Chainman	11	2 50 per day	27 50	5 80	33 30
C. Hurlbut	Chainman	20	2 50 per day	50 00	29 34	79 34
Jay Capron	Chainman	9	5 00 per day	45 00	....	45 00
D. E. Whitford	Chainman	18	5 00 per day	90 00	20 24	110 24
C. A. Cockroft	Chainman	3	4 50 per day	13 50	4 96	18 46
INCIDENTAL EXPENSES.						$4,261 09
Stationery					$207 98	
Office rent					14 00	
Fuel					58 50	
Light					10 20	
Postage and telegraph					145 27	
Miscellaneous					752 95	
						1,188 90
						$5,449 99

ORDINARY REPAIRS—OSWEGO CANAL.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$341 92	$3 40	$345 32
Geo. A. Morris	Resident engineer	....	2,000 00 per year	54 78	18 04	72 82
A C Driscoll	Ass't engineer in charge	5	6 00 per day	30 00	6 35	36 35
Fred. J. Wagner	Rodman	4	3 50 per day	14 00	2 60	16 60
C. K. Munroe	Chainman	20	4 00 per day	80 00	....	80 00
E. J. Berry	Chainman	3	3 50 per day	10 50	4 83	15 33
J. J. Schmid	Chainman	4	2 50 per day	10 00	4 93	14 93
C. Hurlbut	Chainman	6	2 50 per day	15 00	9 09	24 09
D. E. Whitford	Chainman	5	5 00 per day	25 00	2 40	27 40
						$632 84

INCIDENTAL EXPENSES.

Postage and telegraph	$6 00	
Miscellaneous	2 00	
		8 00
		$640 84

ORDINARY REPAIRS—CAYUGA AND SENECA CANAL.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$217 00	$3 87	$220 87
Geo. A. Morris	Resident engineer	....	2,000 00 per year	76 71	17 18	93 89
A. C. Driscoll	Ass't engineer in charge	2	6 00 per day	12 00	3 48	15 48
C. K. Munroe	Chainman	17	4 00 per day	68 00	....	68 00
E. J. Berry	Chainman	1	3 50 per day	3 50	2 30	5 80
J. J. Schmid	Chainman	1	2 50 per day	2 50	2 98	5 48
L. Kavanagh	Chainman	1	2 50 per day	2 50	2 30	4 80
James Thomson	Chainman	1	2 50 per day	2 50	2 98	5 48
						$419 80
INCIDENTAL EXPENSES.						
Postage and telegraph					$4 24	
Miscellaneous					14 10	
						18 34
						$438 14

ORDINARY REPAIRS—BLACK RIVER CANAL.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$164 40	....	$164 40
Geo. A. Morris	Resident engineer	....	2,000 00 per year	109 60	$46 00	155 60
A. C. Driscoll	Ass't engineer in charge	2	6 00 per day	12 00	3 21	15 21
Edwin Styring	Leveler	80	4 50 per day	360 00	26 36	386 36
E. A. Lamb	Rodman	59	3 50 per day	206 50	8 03	214 53
C. K. Munroe	Chainman	18	4 00 per day	72 00	....	72 00
Wm. Rowlands	Chainman	4	2 50 per day	10 00	3 12	13 12
Jay Capron	Chainman	8	5 00 per day	40 00	5 34	45 34
L. K. Devendorf	Chainman	80	2 50 per day	200 00	6 33	206 33
						$1,272 89

INCIDENTAL EXPENSES.

Labor	$1 50	
Office rent	12 33	
Postage and telegraph	2 55	
Miscellaneous	160 56	
		176 94
		$1,449 83

ORDINARY REPAIRS—CAYUGA LAKE INLET.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	$2,000 00 per year	$5 48	$6 01	$11 49
B. F. Bauder	Chainman	11	4 00 per day	44 00	....	44 00
						$55 49
INCIDENTAL EXPENSES.						
Postage and telegraph					$0 44	
Miscellaneous					25	
						69
						$56 18

EXTRAORDINARY REPAIRS—COMPLETION OF HIGHWAY HEAD OF OWAGENA LAKE.

CHAPTER 335, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$6 57	....	$6 57
Geo. A. Morris	Resident engineer	....	2,000 00 per year	10 96	$10 57	21 53
A. C. Driscoll	Ass't engineer in charge	8	6 00 per day	48 00	13 37	61 37
E. A. Lamb	Rodman	2	3 50 per day	7 00	4 56	11 56
E. J. Berry	Chainman	12	3 50 per day	42 00	6 56	48 56
J. J. Schmid	Chainman	2	2 50 per day	5 00	5 06	10 06
Wm. Rowlands	Chainman	5	2 50 per day	12 50	10 12	22 62
						$182 27

EXTRAORDINARY REPAIRS—REBUILDING LOCKS BLACK RIVER CANAL.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$65 76	$4 58	$70 34
Geo. A. Morris	Resident engineer	....	2,000 00 per year	71 24	61 93	133 17
Edwin Styring	Leveler	137	4 50 per day	616 50	71 45	687 95
E. A. Lamb	Rodman	110	3 50 per day	385 00	19 93	404 93
Wm. Rowlands	Chainman	109	2 50 per day	272 50	9 18	281 68
L. Kavanagh	Chainman	5	2 50 per day	12 50	9 26	21 76
L. K. Devendorf	Chainman	110	2 50 per day	275 00	11 08	286 08
Jay Capron	Chainman	77	5 00 per day	385 00	1 52	386 52
C. Hurlbut	Chainman	46	2 50 per day	115 00	4 21	119 21
						$2,391 64
INCIDENTAL EXPENSES.						
Office rent					$41 00	
Postage and telegraph					11 39	
Miscellaneous					345 75	
						$398 14
						$2,789 78

EXTRAORDINARY REPAIRS—CONSTRUCTING DRAIN AT WHITESBORO.

CHAPTER 359, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Paul L. Schultze	Leveler	8	$4 50 per day	$36 00	$2 23	$38 23
John Schimmel	Chainman	1	2 50 per day	2 50	1 20	3 70
						$41 93
INCIDENTAL EXPENSES.						
Miscellaneous						50
						$42 43

EXTRAORDINARY REPAIRS—CLEANING MADISON BROOK FEEDER.

CHAPTER 570, LAWS OF 1894,

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$19 72	$9 10	$28 82
Geo. A. Morris	Resident engineer	....	2.000 00 per year	65 76	58 09	123 85
A. C. Driscoll	Ass't engineer in charge	8	6 00 per day	48 00	20 28	68 28
Edwin Styring	Leveler	2	4 50 per day	9 00	5 02	14 02
Theo. A. Hendrickson	Leveler	2	4 50 per day	9 00	6 66	15 66
E. A. Lamb	Rodman	42	3 50 per day	147 00	11 48	158 48
O. H. Bogardus	Chainman	85	4 50 per day	382 50	10 16	392 66
E. J. Berry	Chainman	6	3 50 per day	21 00	10 88	31 88
J. J. Schmid	Chainman	82	2 50 per day	205 00	29 93	234 93
Wm. Rowlands	Chainman	4	2 50 per day	10 00	11 32	21 32
L. K. Devendorf	Chainman	43	2 50 per day	107 50	6 22	113 72
D. E. Whitford	Chainman	82	5 00 per day	160 00	....	160 00
						$1,363 62

INCIDENTAL EXPENSES.

Labor	$1 50	
Stationery	45	
Office rent	45 00	
Postage and telegraph	5 14	
Miscellaneous	206 40	
		258 49
		$1,622 11

EXTRAORDINARY REPAIRS—PROTECTING CAYUGA AND SENECA CANAL AT GENEVA.

CHAPTER 424, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$26 30	$7 91	$34 21
Geo. A. Morris	Resident engineer	....	2,000 00 per year	54 79	52 64	107 43
A. C. Driscoll	Ass't engineer in charge	6	6 00 per day	36 00	25 82	61 82
Theo. A. Hendrickson	Leveler	2	4 50 per day	9 00	5 98	14 98
E. A. Lamb	Rodman	6	3 50 per day	21 00	2 58	23 58
B. F. Bauder	Chainman	2	4 00 per day	8 00	5 08	13 08
E. J. Berry	Chainman	8	3 50 per day	28 00	19 84	47 84
J. J. Schmid	Chainman	2	2 50 per day	5 00	5 68	10 68
Wm. Rowlands	Chainman	36	2 50 per day	90 00	71 55	161 55
L. Kavanagh	Chainman	21	2 50 per day	52 50	46 75	99 25
D. E. Whitford	Chainman	153	5 00 per day	765 00	24 89	789 89
L. K. Devendorf	Chainman	9	2 50 per day	22 50	....	22 50
James Thomson	Chainman	6	2 50 per day	15 00	....	15 00
						$1,401 81
INCIDENTAL EXPENSES.						
Stationery					$0 30	
Postage and telegraph					1 89	
Miscellaneous					4 65	
						6 84
						$1,408 65

EXTRAORDINARY REPAIRS—STONE DAM AT BALDWINSVILLE.

CHAPTER 113, LAWS OF 1893, AND CHAPTER 130, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$289 32	$16 80	$306 12
Geo. A. Morris	Resident engineer	....	2,000 00 per year	164 38	18 20	182 58
A. C. Driscoll	Ass't engineer in charge	57	6 00 per day	342 00	12 40	354 40
W. W. Jeffers	Assistant engineer	2	5 00 per day	10 00	20	10 20
Edwin Styring	Leveler	8	4 50 per day	36 00	....	36 00
George C. Diehl	Leveler	5	4 50 per day	22 50	10	22 60
E. A. Lamb	Rodman	7	3 50 per day	24 50	....	24 50
Fred. J. Wagner	Rodman	74	3 50 per day	259 00	2 00	261 00
C. K. Munroe	Chainman	54	4 00 per day	216 00	....	216 00
E. J. Berry	Chainman	9	3 50 per day	31 50	....	31 50
Fred. J. Wagner	Chainman	167	2 50 per day	417 50	9 25	426 75
J. J. Schmid	Chainman	55	2 50 per day	187 50	2 00	189 50
Wm. Rowlands	Chainman	19	2 50 per day	47 50	20	47 70
L. Kavanagh	Chainman	14	2 50 per day	35 00	2 00	37 00
C. Hurlbut	Chainman	21	2 50 per day	52 50	1 00	53 50
L. K. Devendorf	Chainman	7	2 50 per day	17 50	....	17 50
D. E. Whitford	Chainman	14	5 00 per day	70 00	....	70 00
C. A. Cockroft	Chainman	16	4 50 per day	72 00	30	72 30
						$2,309 15
INCIDENTAL EXPENSES.						
Labor					$3 00	
Postage and telegraph					9 02	
Miscellaneous					104 00	
						116 02
						$2,425 17

EXTRAORDINARY REPAIRS—REMOVING OBSTRUCTIONS FOOT CAYUGA LAKE.

CHAPTER 279, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
A. C. Driscoll	Ass't engineer in charge	1	$6 00 per day	$6 00	$1 98	$7 98
C. K. Munroe	Chainman	25	4 00 per day	100 00	....	100 00
L. Kavanagh	Chainman	58	2 50 per day	145 00	20 62	165 62
C. Hurlbut	Chainman	1	2 50 per day	2 50	1 61	4 11
						$277 71
INCIDENTAL EXPENSES.						
Miscellaneous						$20 90
						$298 61

EXTRAORDINARY REPAIRS—CLEANING STATE DITCH AT LIVERPOOL.

CHAPTER 119, LAWS OF 1893.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$13 15	....	$13 15
Geo. A. Morris	Resident engineer	....	2,000 00 per year	10 96	....	10 96
A. C. Driscoll	Ass't engineer in charge	6	6 00 per day	36 00	$7 15	43 15
Theo. A. Hendrickson	Leveler	5	4 50 per day	22 50	....	22 50
C. K. Munroe	Chainman	1	4 00 per day	4 00	....	4 00
						$93 76
INCIDENTAL EXPENSES.						
Miscellaneous						$0 07
						$93 83

EXTRAORDINARY REPAIRS—DREDGING CAYUGA LAKE INLET AT ITHACA.

CHAPTER 656, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$13 15	....	$13 15
Geo. A. Morris	Resident engineer	....	2,000 00 per year	5 48	....	5 48
B. F. Bauder	Chainman	53	4 00 per day	212 00	$15 75	227 75
E. J. Berry	Chainman	9	3 50 per day	31 50	....	31 50
						$277 88
INCIDENTAL EXPENSES.						
Postage and telegraph					$0 07	
Miscellaneous					11 90	
						11 37
						$289 85

EXTRAORDINARY REPAIRS—SURVEYS ON ACC'T. ATTORNEY-GENERAL.

CHAPTER 358, LAWS OF 1894, AND CHAPTER 932, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2.400 00 per year	$13 15	....	$13 15
A. C. Driscoll	Ass't engineer in charge	4	6 00 per day	24 00	$12 28	36 28
D. C. Wood	Assistant engineer	41	6 00 per day	246 00	26 12	272 12
Edwin Styring	Leveler	4	4 50 per day	18 00	....	18 00
Paul L. Schultze	Leveler	3	4 50 per day	13 50	1 76	15 26
Wallace Greenalch	Leveler	57	4 50 per day	256 50	10 18	266 68
Arthur O'Brien	Rodman	37	3 50 per day	129 50	5 54	135 04
E. J. Berry	Chainman	1	3 50 per day	3 50	1 00	4 50
J. J. Schmid	Chainman	7	2 50 per day	17 50	....	17 50
Wm. Rowlands	Chainman	1	2 50 per day	2 50	1 00	3 50
L. Kavanagh	Chainman	13	2 50 per day	32 50	....	32 50
C Hurlbut	Chainman	4	2 50 per day	10 00	7 06	17 06
D. E. Whitford	Chainman	1	5 00 per day	5 00	2 08	7 08
James Thomson	Chainman	131	2 50 per day	327 50	18 75	346 25
H. C. Copeland	Chainman	39	2 50 per day	97 50	17 54	115 04
George Trapp	Chainman	9	2 50 per day	22 50	6 74	29 24
William O'Brien	Axeman	30	2 00 per day	60 00	....	60 00
						$1,389 20
INCIDENTAL EXPENSES.						
Postage and telegraph					$2 50	
Miscellaneous					85 74	88 24
						$1,477 44

EXTRAORDINARY REPAIRS—IMPROVING CAYUGA AND SENECA CANAL AT SENECA FALLS.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$177 53	$10 06	$187 59
Geo. A. Morris	Resident engineer	....	2,000 00 per year	164 39	46 22	210 61
A. C. Driscoll	Ass't engineer in charge	17	6 00 per day	102 00	17 48	119 48
Fred. J. Wagner	Rodman	1	3 50 per day	3 50	....	3 50
B. F. Bander	Chainman	174	4 00 per day	696 00	31 48	727 48
E. J. Berry	Chainman	2	3 50 per day	7 00	4 68	11 68
J. J. Schmid	Chainman	10	2 50 per day	25 00	4 40	29 40
Wm. Rowlands	Chainman	24	2 50 per day	60 00	1 34	61 34
L. Kavanagh	Chainman	5	2 50 per day	12 50	12 04	24 54
						$1,375 62
INCIDENTAL EXPENSES.						
Fuel					$4 00	
Postage and telegraph					5 89	
Miscellaneous					19 78	
						29 67
						$1,405 29

EXTRAORDINARY REPAIRS—PIER AND BREAKWATER AT CANANDAIGUA.

CHAPTER 173, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	....	....	$4 00	$4 00

EXTRAORDINARY REPAIRS—GILBERT ST. WALL AT UTICA.

CHAPTER 423, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$19 72	$4 51	$24 23
Geo. A. Morris	Resident engineer	....	2,000 00 per year	54 80	27 64	82 44
A. C. Driscoll	Ass't engineer in charge	3	6 00 per day	18 00	3 36	21 36
Paul L. Schultze	Leveler	139	4 50 per day	625 50	45 18	670 68
L. Kavanagh	Chainman	3	2 50 per day	7 50	10 46	17 96
John Schimmel	Chainman	92	2 50 per day	230 00	6 50	236 50
John Hackett	Chainman	46	2 50 per day	115 00	3 30	118 30
James Thomson.	Chainman	2	2 50 per day	5 00	5 58	10 58
						$1,182 05

INCIDENTAL EXPENSES.

Light	$1 93	
Office rent	28 00	
Postage and telegraph	1 00	
Miscellaneous	3 05	
		33 98
		$1,216 03

EXTRAORDINARY REPAIRS—LIFT BRIDGE AT GEDDES ST., SYRACUSE.

CHAPTER 385, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$184 12	$2 00	$186 12
Geo. A. Morris	Resident engineer	....	2,000 00 per year	235 61	6 50	242 11
A. C. Driscoll	Ass't engineer in charge	37	6 00 per day	222 00	6 55	228 55
W. W. Jeffers	Assistant engineer	6	5 00 per day	30 00	....	30 00
Fred. J. Wagner	Rodman	5	3 50 per day	17 50	....	17 50
E. J. Berry	Chainman	90	3 50 per day	315 00	12 20	327 20
J. J. Schmid	Chainman	9	2 50 per day	22 50	1 70	24 20
Wm. Rowlands	Chainman	2	2 50 per day	5 00	....	5 00
L. Kavanagh	Chainman	75	2 50 per day	187 50	13 80	201 30
C. Hurlbut	Chainman	5	2 50 per day	12 50	7 28	19 78
L. K. Devendorf	Chainman	12	2 50 per day	30 00	30	30 30
James Thomson	Chainman	1	2 50 per day	2 50	10	2 60
John Hackett	Chainman	24	2 50 per day	60 00	....	60 00
C. A. Cockroft	Chainman	6	4 50 per day	27 00	....	27 00
						$1,401 06

INCIDENTAL EXPENSES.

Stationery	$50 45	
Postage and telegraph	11 35	
Miscellaneous	485 72	
		547 52
		$1,949 18

EXTRAORDINARY REPAIRS—SLUICE IN SPILLWAY AT NORTH BRANCH RESERVOIR.

CHAPTER 726, LAWS OF 1893.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	$2,000 00 per year	$76 70	$58 85	$135 55
A. C. Driscoll	Ass't engineer in charge	15	6 00 per day	90 00	36 75	126 75
E. A. Lamb	Rodman	4	3 50 per day	14 00	....	14 00
E. J. Berry	Chainman	6	3 50 per day	21 00	....	21 00
J. J. Schmid	Chainman	4	2 50 per day	10 00	....	10 00
Jay Capron	Chainman	105	5 00 per day	525 00	9 85	534 85
C. Hurlbut	Chainman	79	2 50 per day	197 50	3 98	201 48
						$1,043 63
INCIDENTAL EXPENSES.						
Postage and telegraph					$0 91	
Miscellaneous					63 43	
						64 31
						$1,107 97

EXTRAORDINARY REPAIRS—IMPROVING OSWEGO CANAL.

CHAPTER 119, LAWS OF 1893, AND CHAPTER 219, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$19 72	$14 87	$34 59
Geo. A. Morris	Resident engineer	....	....	....	10 80	10 80
A. C. Driscoll	Ass't engineer in charge	6	6 00 per day	36 00	7 55	43 55
Theo. A. Hendrickson	Leveler	2	4 50 per day	9 00	....	9 00
Fred. J. Wagner	Rodman	3	3 50 per day	10 50	2 40	12 90
J. J. Schmid	Chainman	6	2 50 per day	15 00	3 90	18 90
						$129 74

INCIDENTAL EXPENSES.

Postage and telegraph	$0 35	
Miscellaneous	1 00	
		1 35
		$131 09

EXTRAORDINARY REPAIRS—ROAD BRIDGE AT LIVERPOOL.

CHAPTER 93, LAWS OF 1893.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2.400 00 per year	$6 57	....	$6 57
Geo. A. Morris	Resident engineer	....	2,000 00 per year	5 48	$2 08	7 56
A. C. Driscoll	Ass't engineer in charge	7	6 00 per day	42 00	2 20	44 20
E. J. Berry	Chainman	6	3 50 per day	21 00	1 60	22 60
J J. Schmid	Chainman	3	2 50 per day	7 50	80	8 30
Wm. Rowlands	Chainman	1	2 50 per day	2 50	80	3 30
L. Kavanagh	Chainman	1	2 50 per day	2 50	80	3 30
						$95 83
INCIDENTAL EXPENSES.						
Miscellaneous						4 17
						$100 00

EXTRAORDINARY REPAIRS—CONSTRUCTING HIGHWAY ONONDAGA INDIAN RESERVATION.

CHAPTER 458, LAWS OF 1894, AND CHAPTER 932, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	....	....	$7 50	$7 50
A. C. Driscoll	Ass't engineer in charge	7	$6 00 per day	$42 00	11 75	53 75
E. J. Berry	Chainman	4	3 50 per day	14 00	3 00	17 00
						$78 25

EXTRAORDINARY REPAIRS—MAPS AND MONUMENTS.

CHAPTER 358, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Edwin Styring	Leveler	9	$4 50 per day	$40 50	$35 16	$75 66
Theo. A. Hendrickson	Leveler	7	4 50 per day	31 50	22 82	54 32
L. Kavanagh	Chainman	8	2 50 per day	20 00	19 66	39 66
						$169 64
INCIDENTAL EXPENSES.						
Miscellaneous						1 00
						$170 64

EXTRAORDINARY REPAIRS—DREDGING STATE DITCH BETWEEN SENECA FALLS AND WATERLOO.

CHAPTER 358, LAWS OF 1894, AND CHAPTER 932, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$6 57	$1 68	$8 25
Geo. A. Morris	Resident engineer	....	2,000 00 per year	10 96	1 68	12 64
A. C. Driscoll	Ass't engineer in charge	5	6 00 per day	30 00	8 50	38 50
George C. Diehl	Leveler	18	4 50 per day	81 00	27 40	108 40
E. A. Lamb	Rodman	3	3 50 per day	10 50	2 74	13 24
						$181 03

INCIDENTAL EXPENSES.

Postage and telegraph	$0 59	
Miscellaneous	85	
		1 44
		$182 47

EXTRAORDINARY REPAIRS—STONE APRON TO OSWEGO DAM.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$52 60	$17 85	$70 45
Geo. A. Morris	Resident engineer	....	2,000 00 per year	60 27	47 10	107 37
A. C. Driscoll	Ass't engineer in charge	9	6 00 per day	54 00	20 60	74 60
Edwin Styring	Leveler	76	4 50 per day	342 00	17 30	359 30
George C. Diehl	Leveler	2	4 50 per day	9 00	3 90	12 90
E. A. Lamb	Rodman	1	3 50 per day	3 50	....	3 50
B. F. Bauder	Chainman	60	4 00 per day	240 00	8 25	248 25
E. J. Berry	Chainman	4	3 50 per day	14 00	7 70	21 70
J. J. Schmid	Chainman	1	2 50 per day	2 50	2 40	4 90
Wm. Rowlands	Chainman	5	2 50 per day	12 50	9 30	21 80
L. K. Devendorf	Chainman	1	2 50 per day	2 50	2 40	4 30
Jay Capron	Chainman	70	5 00 per day	350 00	3 04	353 04
						$1,282 71
INCIDENTAL EXPENSES.						
Office rent					$10 00	
Postage and telegraph					75	
Miscellaneous					9 75	20 50
						$1,303 21

EXTRAORDINARY REPAIRS—GENESKE ST. BRIDGE AT UTICA.

CHAPTER 170, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$13 15	$4 25	$17 40
Geo. A. Morris	Resident engineer	....	2,000 00 per year	32 87	24 87	57 74
A. C. Driscoll	Ass't engineer in charge	2	6 00 per day	12 00	7 96	19 96
Paul L. Schultze	Leveler	88	4 50 per day	396 00	23 56	419 56
J. J. Schmid	Chainman	25	2 50 per day	62 50	....	62 50
John Schimmel	Chainman	26	2 50 per day	65 00	40	65 40
C. Hurlbut	Chainman	38	2 50 per day	95 00	30	95 30
D. E. Whitford	Chainman	18	5 00 per day	90 00	3 96	93 96
James Thomson	Chainman	4	2 50 per day	10 00	1 68	11 68
John Hackett	Chainman	101	2 50 per day	252 50	2 50	255 00
						$1,098 50

INCIDENTAL EXPENSES.

Stationery	$0 10	
Office rent	42 00	
Postage and telegraph	5 51	
Miscellaneous	1,339 48	
		1,387 09
		$2,485 59

EXTRAORDINARY REPAIRS—RIVER BRIDGE AT CARTHAGE.

CHAPTER 102, LAWS OF 1895.

NAME	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
A. C. Driscoll	Ass't engineer in charge	8	$6 00 per day	$48 00	$14 37	$62 37
E. J. Berry	Chainman	5	3 50 per day	17 50	13 58	31 08
J. J. Schmid	Chainman	4	2 50 per day	10 00	12 60	22 60
L. Kavanagh	Chainman	5	2 50 per day	12 50	13 58	26 08
						$142 13
INCIDENTAL EXPENSES.						
Miscellaneous						10
						$142 23

EXTRAORDINARY REPAIRS—STEEL APRON TO BRADDOCK'S DAM.

CHAPTER 572, LAWS OF 1894.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	....	....	$8 90	$8 90
A. C. Driscoll	Ass't engineer in charge	2	$6 00 per day	$12 00	3 50	15 50
Fred. J. Wagner	Rodman	7	3 50 per day	24 50	1 50	26 00
E. J. Berry	Chainman	1	3 50 per day	3 50	2 40	5 90
						$56 30
INCIDENTAL EXPENSES.						
Miscellaneous						4 00
						$60 30

EXTRAORDINARY REPAIRS—IMPROVING COWASELON CREEK.

CHAPTER 366, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$13 15	....	$13 15
Geo. A. Morris	Resident engineer	....	2,000 00 per year	10 95	$9 86	20 81
A. C. Driscoll	Ass't engineer in charge	23	6 00 per day	138 00	46 46	184 46
George C. Diehl	Leveler	30	4 50 per day	135 00	11 48	146 48
E. A. Lamb	Rodman	6	3 50 per day	21 00	12 84	33 84
Fred J. Wagner	Rodman	6	3 50 per day	21 00	14 18	35 18
L. K. Devendorf	Rodman	25	3 50 per day	87 50	3 88	91 38
B. F. Bauder	Chainman	2	4 00 per day	8 00	2 84	10 84
E. J. Berry	Chainman	40	3 50 per day	140 00	29 25	169 25
J. J. Schmid	Chainman	11	2 50 per day	27 50	21 68	49 18
Wm. Rowlands	Chainman	29	2 50 per day	72 50	22 80	95 30
L Kavanagh	Chainman	29	2 50 per day	72 50	22 44	94 94
L. K. Devendorf	Chainman	3	2 50 per day	7 50	....	7 50
James Thomson	Chainman	10	2 50 per day	25 00	19 34	44 34
Jay Capron	Chainman	8	5 00 per day	40 00	5 97	45 97
C. A. Cockroft	Chainman	1	4 50 per day	4 50	1 84	6 34
						$1,048 96
INCIDENTAL EXPENSES.						
Miscellaneous						135 45
						$1,184 41

EXTRAORDINARY REPAIRS—REPAIRS TO NORTH BRANCH RESERVOIR.

CHAPTER 148, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$46 03	$10 15	$56 18
Geo. A. Morris	Resident engineer	....	2,000 00 per year	82 24	186 55	268 79
A. C. Driscoll	Ass't engineer in charge	24	6 00 per day	144 00	38 30	182 30
George C. Diehl	Leveler	1	4 50 per day	4 50	....	4 50
Arthur O'Brien	Rodman	7	3 50 per day	24 50	6 02	30 52
E. J. Berry	Chainman	10	3 50 per day	35 00	....	35 00
L. Kavanagh	Chainman	4	2 50 per day	10 00	....	10 00
C. Hurlbut	Chainman	23	2 50 per day	57 50	23 82	81 32
D. E. Whitford	Chainman	23	5 00 per day	115 00	5 12	120 12
						$788 73

INCIDENTAL EXPENSES.

Postage and telegraph	$0 35	
Miscellaneous	6 05	
		6 40
		$795 13

EXTRAORDINARY REPAIRS—REPAIRS TO HIGHWAW AT CAYUGA.

CHAPTER 82, LAWS OF 1895.

NAME.	RANK.	Number of days	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer		$2,000 00 per year	$10 95	$6 28	$17 23
E. A. Lamb	Rodman	4	3 50 per day	14 00	7 98	21 98
Wm. Rowlands	Chainman	4	2 50 per day	10 00	9 46	19 46
L. Kavanagh	Chainman	4	2 50 per day	10 00	7 98	17 98
C. Hurlbut	Chainman	4	2 50 per day	10 00	8 76	18 76
C. A. Cockroft	Chainman	7	4 50 per day	31 50	10 73	42 23
						$137 64
INCIDENTAL EXPENSES.						
Postage and telegraph					$0 25	
Miscellaneous					3 50	
						3 75
						$141 39

EXTRAORDINARY REPAIRS—REPAIRS TO OWASCO LAKE OUTLET.

CHAPTER 99, LAWS OF 1895.

NAME	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	$2,000 00 per year	$5 48	$5 21	$10 69
W. W. Jeffers	Assistant engineer	27	5 00 per day	135 00	13 03	148 03
George C. Diehl	Leveler	2	4 50 per day	9 00	5 29	14 29
Fred. J. Wagner	Rodman	3	3 50 per day	10 50	....	10 50
Wm. Rowlands	Chainman	2	2 50 per day	5 00	5 14	10 14
James Thomson	Chainman	3	2 50 per day	7 50	5 19	12 69
C. Hurlbut	Chainman	5	2 50 per day	12 50	9 05	21 55
						$227 89
INCIDENTAL EXPENSES.						
Postage and telegraph					$0 25	
Miscellaneous					2 40	
						2 65
						$230 54

EXTRAORDINARY REPAIRS—PROTECTING CAYUGA AND SENECA CANAL AT GENEVA.

CHAPTER 142, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	$2,000 00 per year	$10 96	$31 43	$42 39
E. A. Lamb	Rodman	33	3 50 per day	115 50	14 95	130 45
Wm. Rowlands	Chainman	4	2 50 per day	10 00	8 58	18 58
L. Kavanagh	Chainman	3	2 50 per day	7 50	9 78	17 28
D. E. Whitford	Chainman	14	5 00 per day	70 00	3 12	73 12
						$281 82
INCIDENTAL EXPENSES.						
Postage and telegraph					$0 52	
Miscellaneous					3 50	
						4 02
						$285 84

EXTRAORDINARY REPAIRS—LIFT BRIDGE AT GENESEE ST., SYRACUSE.

CHAPTER 311, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	$2,000 00 per year	$5 48	$0 30	$5 78
George C. Diehl	Leveler	3	4 50 per day	13 50	50	14 00
E. A. Lamb	Rodman	1	3 50 per day	3 50	10	3 60
B. F. Bauder	Chainman	3	4 00 per day	12 00	50	12 60
Wm. Rowlands	Chainman	3	2 50 per day	7 50	50	8 00
C. Hurlbut	Chainman	4	2 50 per day	10 00	6 26	16 26
James Thomson	Chainman	3	2 50 per day	7 50	50	8 00
C. A. Cockroft	Chainman	6	4 50 per day	27 00	40	27 40
						$95 54

INCIDENTAL EXPENSES.

Miscellaneous	150 00
	$245 54

EXTRAORDINARY REPAIRS—VERTICAL WALL AT HIGGINSVILLE.

CHAPTER 299. LAWS OF 1895.

NAME.	RANK	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Paul L. Schultze	Leveler	1	$4 50 per day	$4 50	$6 10	$10 60
E. A. Lamb	Rodman	1	3 50 per day	3 50	1 28	4 78
John Hackett	Chainman	1	2 50 per day	2 50	1 26	3 76
INCIDENTAL EXPENSES.						$19 14
Labor					$2 00	
Miscellaneous					1 00	
						3 00
						$22 14

EXTRAORDINARY REPAIRS - VERTICAL WALL AT CLAY ST., UTICA.

CHAPTER 367, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Paul L. Schultze	Leveler	3	$4 50 per day	$13 50		$13 50
George C. Diehl	Leveler	1	4 50 per day	4 50		4 50
E. A. Lamb	Rodman	3	3 50 per day	10 50	$7 38	17 88
Fred. J. Wagner	Rodman	2	3 50 per day	7 00		7 00
E. J. Berry	Chainman	2	3 50 per day	7 00		7 00
John Hackett	Chainman	3	2 50 per day	7 50	40	7 90
						$57 78
INCIDENTAL EXPENSES.						
Labor					$4 00	
Miscellaneous					2 00	6 00
						$63 78

EXTRAORDINARY REPAIRS—OTISCO LAKE INLET BRIDGE.

CHAPTER 497, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$6 57	....	$6 57
Geo. A. Morris	Resident engineer	....	2,000 00 per year	5 48	$19 00	24 48
A. C. Driscoll	Ass't engineer in charge	7	6 00 per day	42 00	25 84	67 84
Fred. J. Wagner	Rodman	3	3 50 per day	10 50	1 44	11 94
E. J. Berry	Chainman	2	3 50 per day	7 00	3 50	10 50
L. Kavanagh	Chainman	2	2 50 per day	5 00	3 50	8 50
C. A. Cockroft	Chainman	18	4 50 per day	81 00	13 19	94 19
						$224 02
INCIDENTAL EXPENSES.						
Postage and telegraph					$0 70	
Miscellaneous					7 65	
						8 35
						$232 37

EXTRAORDINARY REPAIRS—IMPROVING CAYUGA AND SENECA CANAL AT WATERLOO.

CHAPTER 512, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$6 57	$1 80	$8 37
Geo. A. Morris	Resident engineer	....	....	....	6 90	6 90
A. C. Driscoll	Ass't engineer in charge	8	6 00 per day	48 00	....	48 00
B. F. Bauder	Chainman	11	4 00 per day	44 00	9 00	53 00
J. J. Schmid	Chainman	11	2 50 per day	27 50	17 45	44 95
L. Kavanagh	Chainman	2	2 50 per day	5 00	2 74	7 74
C. Hurlbut	Chainman	1	2 50 per day	2 50	2 74	5 24
						$174 20

INCIDENTAL EXPENSES.

Miscellaneous	2 10
	$176 30

EXTRAORDINARY REPAIRS—IMPROVING CAYUGA AND SENECA CANAL AT SENECA FALLS.

CHAPTER 512, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$6 58	$1 68	$8 26
Geo. A. Morris	Resident engineer	....	....	....	6 34	6 34
						$14 60

EXTRAORDINARY REPAIRS—ROAD BRIDGE OVER BUTTERNUT CREEK.

CHAPTER 685, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	$2,000 00 per year	$5 48	$2 00	$7 48
						$7 48

EXTRAORDINARY REPAIRS—IMPROVING CAYUGA AND SENECA CANAL AND SENECA LAKE OUTLET.

CHAPTER 308, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	$2,000 00 per year	$27 39	$29 96	$57 35
W. W. Jeffers	Assistant engineer	17	5 00 per day	85 00	19 73	104 73
E. A. Lamb	Rodman	5	3 50 per day	17 50	11 81	29 31
Fred. J. Wagner	Rodman	5	3 50 per day	17 50	11 93	29 43
J. J. Schmid	Chainman	5	2 50 per day	12 50	11 93	24 43
						$245 25

INCIDENTAL EXPENSES.

Postage and telegraph	$1 31	
Miscellaneous	5 50	
		6 81
		$252 06

EXTRAORDINARY REPAIRS—SWING BRIDGE AT GARDEN ST., ROME.

CHAPTER 965. LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	$2,000 00 per year	$5 48	$6 56	$12 04
						$12 04
INCIDENTAL EXPENSES.						
Miscellaneous						1 50
						$13 54

EXTRAORDINARY REPAIRS—CHANNEL LAKE ONTARIO TO WIGWAM COVE.

CHAPTER 1,009, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$19 73	$8 85	$28 58
E. A. Lamb	Rodman	11	3 50 per day	38 50	11 40	49 90
Jay Capron	Chainman	10	5 00 per day	50 00	7 90	57 90
C. Hurlbut	Chainman	5	2 50 per day	12 50	11 90	24 40
C. A. Cockroft	Chainman	16	4 50 per day	72 00	23 30	95 30
						$256 08

INCIDENTAL EXPENSES.

Miscellaneous	4 85
	$260 93

EXTRAORDINARY REPAIRS—PILING OUTLET LAKE KEUKA.

CHAPTER 1,009, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$6 57	....	$6 57
Geo. A. Morris	Resident engineer	....	2,000 00 per year	10 96	13 40	24 36
A. C. Driscoll	Ass't engineer in charge	4	6 00 per day	24 00	7 48	31 48
E. J. Berry	Chainman	7	3 50 per day	24 50	6 98	31 48
						$93 89
INCIDENTAL EXPENSES.						
Postage and telegraph					$0 81	
Miscellaneous					2 35	3 16
						$97 05

EXTRAORDINARY REPAIRS—REBUILDING LOCKS BLACK RIVER CANAL.

CHAPTER 1,030, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
W. H. H. Gere	Division engineer	....	$2,400 00 per year	$19 73	$6 62	$ 26 35
A. C. Driscoll	Ass't engineer in charge	2	6 00 per day	12 00	....	12 00
George C. Diehl	Leveler	1	4 50 per day	4 50	....	4 50
						$42 85
INCIDENTAL EXPENSES.						
Postage and telegraph					$1 94	
Miscellaneous					12 00	
						13 94
						$56 79

EXTRAORDINARY REPAIRS—BRIDGE SURVEY FOOT CAYUGA LAKE.

CHAPTER 719, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident Engineer	....	$2,000 00 per year	$27 39	$19 38	$46 77
A. C. Driscoll	Ass't engineer in charge	6	6 00 per day	36 00	13 77	49 77
George C. Diehl	Leveler	8	4 50 per day	36 00	13 96	49 96
E. A. Lamb	Rodman	5	3 50 per day	17 50	10 23	27 73
Fred. J. Wagner	Rodman	4	3 50 per day	14 00	6 46	20 46
B. F. Bauder	Chainman	1	4 00 per day	4 00	1 40	5 40
E. J. Berry	Chainman	13	3 50 per day	45 50	15 46	60 96
Wm. Rowlands	Chainman	2	2 50 per day	5 00	4 93	9 93
L. Kavanagh	Chainman	9	2 50 per day	22 50	17 78	40 28
C. Hurlbut	Chainman	5	2 50 per day	12 50	12 04	24 54
C. A. Cockroft	Chainman	11	4 50 per day	49 50	11 98	61 48
						$397 28

INCIDENTAL EXPENSES.

Postage and telegraph	$0 52	
Miscellaneous	14 75	
		15 27
		$412 55

EXTRAORDINARY REPAIRS—GILBERT ST. WALL AT UTICA.

CHAPTER 968, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
George C. Diehl	Leveler	1	$4 50 per day.......	$4 50	....	$4 50

EXTRAORDINARY REPAIRS—IMPROVING CHANNEL BUTTERNUT CREEK.

CHAPTER 1,009, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer	....	....	....	$3 50	$3 50

EXTRAORDINARY REPAIRS—CLEANING DITCH TOWN OF ELBRIDGE.

CHAPTER 932, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
Geo. A. Morris	Resident engineer				$2 88	$2 88
A. C. Driscoll	Ass't engineer in charge	1	$6 00 per day	$6 00	88	6 88
						$9 76

EXTRAORDINARY REPAIRS—CANASARAGA CREEK CULVERT.

CHAPTER 969, LAWS OF 1895.

NAME.	RANK.	Number of days.	Rate of compensation.	Salary.	Travel.	Total.
A. C. Driscoll	Ass't engineer in charge	3	$6 00 per day	$18 00		$18 00
W. W. Jeffers	Assistant engineer	3	5 00 per day	15 00		15 00
George C. Diehl	Leveler	1	4 50 per day	4 50	92	5 42
Fred. J. Wagner	Rodman	1	3 50 per day	3 50	1 84	5 34
						$43 76

SUMMARY.

ITEMS.	Authorized by		Amount.	Total.
	Chap.	Year.		
Ordinary Repairs.	297	1894		
Erie canal			$5,449.99	
Oswego canal			640.84	
Cayuga and Seneca canal			438.14	
Black river canal			1,449.83	
Cayuga lake inlet			56.18	
				$8,034.98
Extraordinary Repairs.				
Erie Canal.				
Completion of highway head of Owagena lake	335	1894	$182.27	
Constructing drain at Whitesboro	359	1894	42.43	
Cleaning Madison brook feeder	570	1894	1,622 11	
Lift bridge at Geddes street, Syracuse	385	1894	1,949.18	
Gilbert street wall at Utica	423	1894	1,216.03	
Genesee street bridge at Utica	170	1895	2,485.59	
Improving Cowaselon creek	366	1895	1,184.41	
Repairs to Owasco lake outlet	99	1895	230.54	
Vertical wall at Higginsville	299	1895	22.14	
Lift bridge at Genesee street, Syracuse	311	1895	245.54	
Vertical wall at Clay street, Utica	367	1895	63.78	
Otisco lake inlet bridge	497	1895	232.37	
Road bridge over Butternut creek	685	1895	7.48	
Cleaning lake brook ditch	678	1895	59.40	
Cleaning Manlius ditch	851	1895	179.55	
Gilbert street wall at Utica	968	1895	4.50	
Improving channel Butternut creek	1,009	1895	3.50	
Cleaning ditch, town of Elbridge	932	1895	9.76	
Canasaraga creek culvert	969	1895	43.76	
				9,784.34
Oswego Canal.				
Stone dam at Baldwinsville	113 130	1893 1894	$2,425.17	
Cleaning State ditch at Liverpool	119	1893	98.83	
Improving Oswego Canal	119 219	1893 1895	181.09	
Road bridge at Liverpool	93	1893	100.00	
Stone apron to Oswego dam	572	1894	1,303.21	
Steel apron to Braddocks' dam	572	1894	60.30	
				4,113.60
Black River Canal.				
Rebuilding locks, Black river canal	572	1894	$2,789.78	
Surveys on account Attorney-General	358 932	1894 1895	1,477.44	
Sluice in spillway at North Branch reservoir	726	1893	1,107.97	
River bridge at Carthage	102	1895	142.23	
Repairs to North Branch reservoir	148	1895	795.13	
Swing bridge at Garden street, Rome	965	1895	13.54	
Rebuilding locks, Black river canal	1,030	1895	56.79	
				6,382.88
Cayuga and Seneca Canal.				
Protecting Cayuga and Seneca canal at Geneva	424	1894	$1,408.65	
Dredging Cayuga lake inlet at Ithaca	656	1894	289.85	
Improving Cayuga and Seneca canal at Seneca Falls	572	1894	1,405.29	
Dredging State Ditch between Seneca Falls and Waterloo	358 932	1894 1895	182.47	
Repairs to highway at Cayuga	82	1895	141.39	
Protecting Cayuga and Seneca canal at Geneva	142	1895	285.84	
Improving Cayuga and Seneca canal at Waterloo	512	1895	176.30	
Forward			$3,889.79	$28,315.80

SUMMARY.—(Continued.)

ITEMS.	Authorized by		Amount.	Total.
	Chap.	Year.		
Forward			$3,889.79	$28,315.80
Improving Cayuga and Seneca canal at Seneca Falls	512	1895	14.60	
Improving Cayuga and Seneca canal and Seneca lake outlet	308	1895	252.06	
Removing obstructions, foot Cayuga lake	279	1894	298.61	
				$4,455.06
Miscellaneous.				
Pier and breakwater at Canandaigua	173	1894	$4.00	
Constructing highway, Onondaga Indian reservation	458 932	1894 1895	78.25	
Maps and monuments	358	1894	170.64	
Channel Lake Ontario to Wigwam Cove	1,009	1895	260.93	
Piling outlet Lake Keuka	1,009	1895	97.05	
Bridge survey foot Cayuga lake	719	1895	412.55	
				$1,023.42
Total abstracts rendered during fiscal years 1894 and 1895				$33,794.28

TABLE NO. 2.

STATEMENT OF CONTRACTS IN FORCE OCTOBER 1, 1895.

NAME OF CONTRACTORS.	Date of Contract.	Character of Work.	ACT.		Appropriation.	Engineer's estimate.	Engineer's estimate at contract price.	Payment to Sept. 30, 1895.
			Chap.	Year.				
James B. Donnelly	Nov. 1, 1894	Stone Apron to Oswego Dam	572	1894	$30,000 00	$24,185 00	$23,208 00	$19,907 00
Edward S. Candee	Aug. 2, 1895	Otisco Lake Inlet Bridge	497	1895	8,000 00	7,964 00	6,209 00	1,105 00
E. H. Fleming & Co.	Aug. 6, 1895	Protecting Cayuga and Seneca Canal at Geneva	142	1895	15,000 00	15,000 00	10,943 00	2,465 00
Michael Bennett	Aug. 28, 1895	Road over Spillway at N. Branch Reservoir	148	1895	25,000 00	3,853 50	5,137 17	1,411 00
John H. Nelson	Aug. 29, 1895	Discharge Pipes at N. Branch Reservoir	148	1895		17,983 50	16,764 50	....
E. S. Gay	Aug. 29, 1895	State Ditch at Cowaselon Swamp	366	1895	30,000 00	29 925 00	21,350 00	1,360 00
J. J. Hallock	Aug. 30, 1895	Repairs to Owasco Lake Outlet	99	1895	12,000 00	12,000 00	8,842 88	442 00
Geo. W. Barlow	Aug. 30, 1895	Improving Cayuga and Seneca Canal at Waterloo	572 512	1894 1895	20,000 00	14,297 50	7,837 00	221 00
Willard Johnson	Aug. 31, 1895	Improving Cayuga and Seneca Canal at Seneca Falls	512	1895		12,166 00	8,230 50	425 00
Dodge & MacGregor	Sept. 7, 1895	Rebuilding combined Locks 38-43 B.R. Canal.	1030	1895	45,000 00	45,000 00	38,881 50	....
Hughes Bros	Sept. 9, 1895	Steel Apron to portion Braddock's Dam	572 368	1894 1895	25,000 00	16,475 00	14,756 00	1,275 00
James J. Dwyer	Sept. 17, 1895	Vertical Wall at Gilbert St., Utica	968	1895	10,000 00	9,993 50	7,384 95	....
Lauer & Hagaman Brayer & Albaugh	Sept. 20, 1895	Vertical Wall at Clay St., Utica	367	1895	2,500 00	2,499 50	2,042 25	....
Lauer & Hagaman Brayer & Albaugh	Sept. 20, 1895	Piling Outlet, Lake Keuka	1009	1895	8,500 00	8,414 00	6,309 00	....
Lauer & Hagaman Brayer & Albaugh	Sept. 20, 1895	Vertical Wall at Higginsville	299	1895	2,500 00	2,399 00	1,849 50	....
John Hannan	Sept. 3, 1895	Opening Channel at Wigwam Cove, Lake Ontario	1009	1895	10,000 00	10,000 00	8,250 00	....
E. H. Fleming & Co.	Oct. 1, 1895	Improving Cayuga and Seneca Canal and Seneca Lake Outlet	308	1895	20,000 00	13,600 00	10,041 70	442 00

TABLE NO. 3.

STATEMENT OF CONTRACTS COMPLETED AND SETTLED DURING THE YEAR.

NAME OF CONTRACTORS.	Date of Contract.	Character of Work.	ACT.		Appropriation.	Engineer's estimate.	Amount of final account.
			Chap.	Year.			
Hughes Bros. & Bangs	Aug. 14, 1893	Stone Dam at Baldwinsville	113 130	1893 1894	$35,000 00 25,000 00	$60,000 00	$56,041 95
Hilton Bridge Construction Co.	Nov. 15, 1893	Two lift and one fixed bridge over Erie Canal at Utica.	560	1893	*45,000 00	....	48,920 74
A. C. Hall	Sept. 11, 1894	Sluice in N. Branch Reservoir	726	1893	8,500 00	7,992 60	6,175 69
A. Van Wagner & Co.	July 23, 1894	Lock No. 18, Black River Canal	572	1894	55,000 00	18 837 50	17,502 90
Mulcahy & Co	July 23, 1894	Lock No. 28, Black River Canal	572	1894		17,770 50	17,201 59
Mulcahy & Co.	July 23, 1894	Lock No. 37, Black River Canal	572	1894		17,094 00	14,619 36
J. J. Hallock	Aug. 23, 1894	Removing obstruction, foot of Cayuga Lake	279	1894	4,000 00	4,000 00	3,018 60
Brayer & Albaugh	Oct. 5, 1894	Protecting Berme Bank, Cayuga and Seneca Canal. at Geneva	424	1894	15,000 00	13,853 50	12,491 89
Hingston & Woods	Aug. 23, 1894	Removing bars and dredging channel of Cayuga Inlet	656	1894	5,000 00	5,000 00	3,802,14
Edward S. Candee	Sept. 27, 1894	Repairs to Madison and Lebanon Feeders	570	1894	10,000 00	9,924 44	8,837 79
Brummelkamp & Lane	Oct. 26, 1894	Removing Superstructure at Geddes St., and re-erecting at Liverpool	93	1893	1,500 00	1,465 00	1,103 87
Edward S. Candee	Mch. 21, 1894	Rebuilding berme abutment, Main St. Bridge at Jordan	297	1894	....	3.382 00	5,957 76
G. W. Barlow	Oct. 30, 1894	Improving Cayuga and Seneca Canal at Seneca Falls.	572	1894	15,000 00	12,438 00	7,091 75
Martin & Sullivan	Dec. 6. 1894	Substructure of Lift Bridge at Geddes St., Syracuse.	385	1894	† 15,000 00	6,873 00	4,906 90
Wrought Iron Bridge Co	Dec. 28, 1894	Superstructure " " " "	385	1894			7,634 62
James J. Dwyer	Oct. 25, 1894	Vertical wall on berme side Erie Canal, between Gilbert and Turner sts., Utica	423	1894	10,000 00	9,795 00	7,958 27
Hilton Bridge Co.	Mch. 26, 1895	Taking out and removing machinery for operating Lift Bridge at Utica and substituting Air Compressor	170	1895	18,000 00	....	9,755 15

* City of Utica appropriated $15,000.00 of this sum.

† City of Syracuse paid one-half the cost of Geddes St. Bridge.

TABLE NO. 4.

WATER RECORD OF CAYUGA AND CROSS LAKES AND SENECA RIVER, AS PER CONCURRENT RESOLUTION OF 1884.

(Water surface given below datum line.)

LOCATION.	Bench-mark number.	Miles from Cayuga lock.	1884.				1885.					
			AUGUST 5, 6 AND 7.		DECEMBER 2, 3 AND 4.		MARCH 4, 5, 6 AND 7.		AUGUST 6 AND 7.		DECEMBER 2, 3 AND 4.	
			WATER.		WATER.		WATER.		WATER.		WATER.	
			Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.
Cayuga lake	1	0	— 8.50	10.49	—10 11	8.97	—10.00	9.08	— 9.33	9.75	— 8.78	10.30
Mud lock	2	1½	— 8.80	10.42	—10.22	9 00	—10.17	9.05	— 9.54	9.68	— 8.91	10.31
Canandaigua river, south of canal	......	6½	—11.20	5.60	—12.68	4.00	—12.54	4.60	—11.93	5.20	—11.09	6.10
Aqueduct	3	6½	—11.42	7.03	-12 98	5.47	—12.66	5.70	— 2.19	6.20	—11.26	7.00
Canandaigua river, north of canal	......	6½	—11.58	5 40	—13.01	4.00	—12.83	4.90	—12.48	5.20	—11.48	6.20
West Shore railroad crossing	4	9	—11.85	3.75	—13.20	2.40	—12.70	2.80	—12.88	2.60	—11 48	3.60
			....	7 80	....	6.50	....	7.70	....	7.50	....	8.50
N. Y. C. & H. R. R. R. crossing	5	10	—12.41	4.80	—14 19	3.00	—13.48	3.90	—13 48	3.90	—12.66	4.70
Mosquito point	6	15¼	—15.92	0.10	—16.81	*	—16.70	*	—16.04	*	—14.23	1.80
			....	7.20	....	6.30	....	6.40	....	7.10	....	8.90
Cross lake	7	25	—17.32	19.20	—17.55	19.00	—18.00	18.50	—17.85	18.70	—15.38	21.10

* Above water.

TABLE NO. 4.

WATER RECORD OF CAYUGA AND CROSS LAKES AND SENECA RIVER, ETC.—(*Continued*).

LOCATION.	1886.						1887.					
	MARCH 8 AND 9.		AUGUST 5, 6 AND 7.		DECEMBER 7.		MARCH 4.		AUGUST 5.		DECEMBER 2.	
	WATER.		WATER.		WATER.		WATER.		WATER.		WATER.	
	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.
Cayuga lake	— 8.11	10.97	— 8.49	10.59	— 8.33	10.75	— 6 82	12.39	— 8.22	10.86	— 9.75	9.33
Mud lock	— 8.26	10.96	— 8.76	10.46	— 8.46	10.76	— 6.82	12.40	— 8 35	10.87	— 9.97	9.25
Canandaigua river, south of canal	— 9.61	7.60	—11.88	5.40	—10.20	7.00	— 7.89	9.30	—10.87	6.30	....	....
Aqueduct	— 9.72	8.70	—12.12	6.30	—10.35	8.10	— 8.14	10.30	—11.09	7.30	—12.42	6.00
Canandaigua river, north of canal	— 9.98	7.80	—12.24	5.40	—10.59	7.10	— 8.30	9.40	—11.51	6 20	—12.64	5.1
West Shore railroad crossing	—10.24	5.20	—12.76	2.70	—10.79	4.50	— 8.82	6.70	—12.00	3.50	—12.91	2.6
	....	10.50	....	7.60	....	9.40	....	11.60	.. ..	8.40	....	7.5
N. Y. C. & H. R. R. R. crossing	—10.74	6.60	—13.31	4.00	—11.61	5.70	— 9 18	8.10	—12.55	4.80	—13.67	3.7
Mosquito point	—12.15	4.00	—16 26	*	—13.89	2.60	—10.52	5.50	—15.41	0.60	—16.57	*
	....	11.00	....	7.00	....	9.70	....	12.60	....	7.70	....	6.5
Cross lake	—14.01	22.50	—17.71	18.80	—15.39	21.10	—12.09	24.40	—17.17	19.30	—17.42	19.1

* Above water.

TABLE NO. 4.

WATER RECORD OF CAYUGA AND CROSS LAKES AND SENECA RIVER, ETC.—(*Continued*).

LOCATION.	1888.						1889.					
	MARCH 2.		AUGUST 6.		DECEMBER 3 AND 4.		MARCH 5 AND 6.		AUGUST 5.		DECEMBER 4 AND 5.	
	WATER.		WATER.		WATER.		WATER		WATER.		WATER.	
	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.
Cayuga lake	— 9.00	10.08	— 8.88	10.20	— 9.28	9.80	— 8.93	10.15	— 6.92	12.16	— 6.56	12.52
Mud lock	— 9.11	10.11	— 9.09	10.13	— 9.48	9.74	— 9.04	10.18	— 7.00	12.22	— 6.96	12.26
Canandaigua river, south of canal	—10.14	7.00	—11.42	5.7	—10.66	6.5	— 9.88	7.26	— 8.82	8.3	— 8.29	8.8
Aqueduct	—10.26	8.1	—11.63	6.8	—10.84	7.6	—10.07	8.29	— 9.03	9.4	— 8.56	9.9
Canandaigua river, north of canal	—10.57	7.2	—11.98	5.7	—11.12	6.6	—10.28	7.44	— 9.33	8.4	— 8.73	9.0
West Shore railroad crossing	—10.96	4.5	—12.29	3.2	—11.35	4.1	—10.47	5.0	— 9.84	5.7	— 8.74	6.8
	....	9 4	....	8.1	....	9.0	....	9.9	....	10.6	....	11.7
N. Y. C. & H. R. R. R. crossing	—11.45	5.9	—13.00	4.4	—12.19	5.2	—10.97	6.4	—10.47	7.0	— 9.17	8.2
Mosquito point	—13.22	2.8	—15.68	0.4	—14.69	1.3	—12.25	3.8	—12.92	3.1	—10.59	5 4
	....	9.9	....	7.5	....	8.4	....	10.9	....	10.2	....	12.5
Cross lake	—14.53	2.2	—17.40	19.1	—14.88	21.67	—14.18	23.4	—13.32	23.2	—11.75	24.8

TABLE NO. 4.

WATER RECORD OF CAYUGA AND CROSS LAKES AND SENECA RIVER, ETC.—(*Continued*).

LOCATION.	1890.						1891.					
	MARCH 6 AND 7.		AUGUST 8.		DECEMBER 4 AND 5.		MARCH 3 AND 6.		AUGUST 3 AND 4.		DECEMBER 9 AND 10.	
	WATER.		WATER.		WATER.		WATER.		WATER.		WATER.	
	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.
Cayuga lake	— 7.41	11.67	— 7.47	11.61	— 7.46	11.62	— 5.89	13.19	— 8.96	10.12	— 9.52	9.56
Mud lock	— 7.55	11.67	— 7.67	11 55	— 7.60	11.62	— 5.96	13.26	— 9.27	9.95	— 9.66	9.56
Canandaigua river, south of canal	— 8.92	8.2	—10.51	6.6	— 9.46	7.7	— 7.16	10.0	—12.69	4.4	—12.12	5.0
Aqueduct	— 9.23	9.2	—10.78	7.6	— 9.79	8.6	— 7.48	10.9	—12.71	5.7	—12.30	6.1
Canandaigua river, north of canal	— 9.27	8.4	—11.28	6.5	— 9.98	7.7	— 7.45	10.2	—12.97	4.7	—12.46	5.2
West Shore railroad crossing	— 9.75	5.8	—11.50	4.0	—10.34	5.2	— 7.65	6 0	—13.29	2.3	—12.66	2.9
	....	10.7	....	8.9	....	10.1	....	12.8	....	7.1	....	7.7
N. Y. C. & H. R. R. R. crossing	— 9.78	7.6	—12.31	5.1	—10.61	6 8	— 7.84	7.9	—13.92	3.5	—13.63	3.8
Mosquito point	—10.91	5.1	—15.16	0.8	—11.33	4.7	— 8.64	7.4	—16.70	Bed dry	—15.47	0.5
	....	12.2	....	7.9	....	11.8	....	14.5	....	6.4	....	7.6
Cross lake	—12.95	23 6	—16.28	20.3	—13.37	23.1	—10.4	26.0	—17.48	19.0	—16.22	20.3

TABLE NO. 4.

WATER RECORD OF CAYUGA AND CROSS LAKES AND SENECA RIVER, ETC.—(*Continued*).

LOCATION.	1892.						1893.					
	MARCH 7 AND 10.		AUGUST 4.		DECEMBER 7.		MARCH 3 AND 4.		AUGUST 7 AND 8.		DECEMBER 6 AND 7.	
	WATER.		WATER.		WATER.		WATER.		WATER.		WATER.	
	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth	Surface.	Depth.
Cayuga lake	— 8.67	10.41	— 7.69	11.39	— 9.06	10.02	— 9.46	9.62	— 8.29	10.78	—10.01	9.1
Mud lock	— 8.79	10.43	— 7.85	11.35	— 9.33	9.89	— 9.55	9.67	— 8.63	10.60	—10 14	9.85
Canandaigua river, south of canal	—10 55	6.5	— 9.56	7.5	—10.54	6.5	—10.84	6.2	—11.190	5.8	—12.19	5.20
Aqueduct	—10.80	7.6	—11.05	7.4	—11.54	6.9	—11.19	7.2	—11.95	6.5	—13.25	5.40
Canandaigua river, north of canal	—11.06	6 6	—11.28	6.4	—11.60	6.1	—11 35	6.3	—12.00	5 7	—13.27	5.00
West Shore railroad crossing	—10.77	4.8	—11.64	4.5	—12.50	4.2	—11.71	8.8	—12.42	3.1	—13.29	4.95
	....	9.6	....	8.7	....	7.9	....	8.7	....	8.0	....	9.70
N. Y. C. & H. R. R. R. crossing	—11.81	5 7	—12.12	3.3	—13.20	4.2	—12.43	5.0	—13.13	4.3	—13 96	6.70
Mosquito point	—12.96	8.0	—14.91	1.1	—14.51	1.5	—14.48	1.5	—15.380	0.6	—16.05	Bed dry
	....	10.1	....	8.2	....	8.6	....	8.6	.. ..	7.7	....	6.1
Cross lake	—13.75	22.7	—16.56	20.0	—15.61	20.9	—15.78	20.7	—17 04	19.5	—16.76	18 6

TABLE NO. 4.

WATER RECORD OF CAYUGA AND CROSS LAKES AND SENECA RIVER, ETC.—(*Concluded*).

LOCATION.	1894.						1895.				REMARKS.
	MARCH 6 AND 7.		AUGUST 7 AND 8.		DECEMBER 6 AND 7.		MARCH 7 AND 8.		AUGUST 6 AND 7.		
	WATER.		WATER.		WATER.		WATER.		WATER.		
	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	Surface.	Depth.	
Cayuga lake	— 9.04	10.88	— 7.66	11.70	— 9.21	9.87*	— 9.09	9.99	— 9.01	10.07	Depth on lock miter-sill.
Mud lock	— 8.99	10.79	— 7.87	11.40	— 9.40	9.80	— 9.18	10.04	— 9.40	9.82	Depth on miter-sill.
Canandaigua river, south of canal	— 9.34	7.90	—10.33	6.00	—11.06	5.10	— 9.75	7.40	—11.99	5.00	Depth of river.
Aqueduct	— 9.60	7.40	—10.95	6.50	—12.33	6.10	—10.24	8 20	—12.97	5.47	Depth on aqueduct foundation.
Canandaigua river, north of canal	— 9.77	8.80	—11.19	5.10	—12.12	4 10	—10.46	7.20	—12.87	4.70	Depth of river.
West Shore railroad crossing	— 9.76	8.80	—11.79	4.90	—12.51	5.70	—10.66	8.20	—13.27	2.40	Depth on natural bed.
	....	10.60	....	8.90	....	......	....	......	....	......	Depth in channel dredged.
N. Y. C. & H. R. R. R. crossing	—10.25	10.40	—12.50	6.50	—13.34	6.8	—11.30	9.7	—13.75	3.55	Depth on bridge foundation.
Mosquito point	—11.94	5.30	—14.22	Edge.	—14.08	Edge.	—13.08	3.1	—16.01	Dry.	Depth on natural bed.
	....	11.40	....	8.0	....	8.50	....	10.1	....	......	Depth in channel dredged.
Cross lake	—12.66	2.27	—16.84	0.4	—16.54	0.5	—14.74	1.5	—18.15	13.35	Depth at iron bridge.

APPENDIX D.

REPORT

OF THE

DIVISION ENGINEER

OF THE

WESTERN DIVISION,

FOR THE

YEAR ENDING SEPTEMBER 30, 1895.

APPENDIX D.

ROCHESTER, *December* 15*th*, 1895.

Hon. CAMPBELL W. ADAMS, *State Engineer and Surveyor:*

Sir:— I have the honor of submitting to you my report on the western division of the State canals for the fiscal year ending September 30, 1895:

The canal slips and navigable feeders are as follows:

	Miles.
Erie canal from the east line of Wayne county to Hamburg street, in the city of Buffalo	148.92
Five slips in the city of Buffalo, aggregate length	1.60
Genesee river feeder, in the city of Rochester	2.25
Total	152.77

UNNAVIGABLE FEEDERS.

Tonawanda and Oak Orchard	11.55
Genesee Valley canal, from Cuba reservoir to lock 87, Rockville	7.65
Genesee Valley canal, from Scottsville to Rochester Rapids dam	11.00
Total	30.20

The sources of water supply for the Erie canal are as follows:

1. Lake Erie, at Buffalo.
2. Tonawanda creek, at Pendleton.
3. Tonawanda and Oak Orchard creek, at Medina.
4. Allen's creek, through the Genesee Valley canal and Genesee river feeder, from Scottsville to Rochester; this water is connected from the Genesee Valley canal by pipe, across the Genesee

river to the feeder below the Rapids dam, and thence into the canal.

5. The Cuba reservoir, in Allegany county, through the Genesee Valley canal and the Genesee river to Rochester, and through the Genesee river feeder in the city of Rochester, into the canal. The Tonawanda and Oak Orchard feeder and the Genesee river assist in filling the canal in the spring; the water from Allen's creek, at Scottsville, which is taken into the feeder at Rochester, tends to keep the water in the feeder pure during the summer months.

Dams.

There are six dams on the division, as follows:

1. One across Tonawanda creek, near its mouth; it raises the waters in the creek about four feet above the level of Niagara river.

2. One across the same creek south of Medina; its purpose is to turn the waters of the creek into the feeder, and through it into the channel of Oak Orchard creek, and thence into the canal at Medina.

3. One across Allen's creek, in the village of Scottsville, to send the water through the Genesee Valley canal, which is now used as a feeder from Scottsville to Rochester.

4. One across the Genesee river at Rochester, to turn the water of that stream into the feeder.

5. One across Oil creek, near the village of Cuba, Allegany county, to hold the waters of that creek and form a reservoir; it is composed of earth, faced with rip-rap and slope wall, and is 2,200 feet long and sixty-five feet in height, where it crosses the stream.

6. One across a valley, two miles from the last mentioned one; it has a waste weir, composed of stone, to serve as an escape for the waters of the creek when the reservoir is full.

Locks.

There are twenty-three locks on this division, and all lock down toward tide-water:

NO.	Location.	Lift in Feet
53.	One and one-fourth miles west of Clyde (lengthened)..	4.755
54.	At lock Berlin (lengthened)........................	7.360
55.	In the village of Lyons (lengthened)...............	6.251
56.	Poorhouse, one and seven-tenths miles west of Lyons, (lengthened)................................	9.848
57.	Lower lock at Lockville, near Newark (not lengthened)	8.028
58.	Middle lock at Lockville, near Newark (not lengthened)	8.004
59.	Upper lock at Lockville, near Newark (not lengthened)	8.002
60.	Eight-tenths of a mile east of Macedon (lengthened)..	9.886
61.	In the village of Macedon (lengthened)...............	6.601
62.	Two and one-quarter miles west of Pittsford (lengthened)................................	8.807
63.	Miller's lock in the village of Brighton (lengthened)..	8.719
64.	Sipple's lock, in the village of Brighton (lengthened)..	10.108
65.	Reservoir lock in the city of Rochester (lengthened)..	10.102
66.	First lock in the city of Rochester (lengthened)......	8.859
67-71.	Five combined locks at Lockport (not lengthened)..	57.427
	One guard-lock at Sulphur Springs; it has one chamber, 110x20 feet, and two additional headgates. These gates are closed when a flood occurs in Tonawanda creek; otherwise they are left open.	
	One river lock at Tonawanda, connecting the Niagara river with canal; the lift is generally four feet, depending on height of water in river.	
	One double chamber guard and lift-lock (lengthened), at Black Rock (No. 72); it is 112x20 feet. The lift, together with the fall in the harbor from the canal below the mean low waters in the lake is..........................	2.425
	Total......................................	175.182

By adding to the above lifts the surface descent on the different levels, we get the total descent on the division:

On Montezuma level..............................	.196
On Twelve-mile level, Nos. 59 to 60............	.165
On Seventeen-mile level, Nos. 61 to 62..........	.343

On Three-mile level, Nos. 62 to 63	.063	
On long level, Rochester to Lockport, Nos. 66 to 67	3.165	
On level between Lockport and Black Rock	1.239	
		5.171
Total rise going west		180.353

There is also one single chamber ship lock from Black Rock harbor to Niagara river; it is 200x36 feet. The lift is usually four feet, depending on the height of water in the lake and river. The weighlock, in the city of Rochester, has not been used as such for some years.

Repairs to Locks.

New tumble gate platforms, wedges, caps and tumble gates were put in locks 53 and 58.

New lower gates were put in locks 53 and 60.

New upper gates and miter sills were put in lock 65.

Two new balance beams were put in locks 58, 59 and 61, one on 63 and 64, and four on the Black Rock locks.

New wedge plates and caps were put on locks 54 and 60.

New gearing and drain to water power were put on locks 54 and 59.

The gearing on tumble gates to locks 53, 55 and 56 were repaired.

The upper gates on locks 62, 63 and on the ship locks were retimbered and replanked.

Two new paddles were put in locks 62 and 64 and in the river locks at Tonawanda, and one on locks 63 and 65.

Four new boxes were put in locks 62 and 64.

On the combined locks at Lockport, the archways were repaired, nine new valves were put in and new heel and tow posts set.

All the locks have been repointed where necessary.

Repairs to Locks Needed.

The combined locks at Lockport need a thorough overhauling. The south wall of lock 71 needs rebuilding. The wall between the combined locks and the race-way is badly cracked and needs rebuilding. Every winter the frost, in spite of braces, cracks this wall more and it is only a question of time when the wall will fall. Nearly all of the locks of the division should have the joints in the masonry scraped out and repointed in a more thorough manner than has been done in the past. Some of the locks which leak badly, should have concrete put in the rear of the walls before the repointing is done.

Repairs to Aqueducts.

The inside of the trunk of the Rochester aqueduct has been cleaned, repointed and the botton cemented. The leakage has been stopped to a great extent.

Repairs to Aqueducts Needed.

The Lyons aqueduct should have new floor timbers and new planking.

Bridges.

There are 109 bridges of cast iron, 58 of wrought iron, 21 of wood and iron, and 34 of wood, a total of 222, on this division. Of these, 2 of wrought iron are over the Commercial slip; 1 of cast and 3 of wrought iron over the Ohio slip; 3 of cast and 2 of wrought iron over the Hamburg canal; 3 of cast and 1 of wrought iron over the Clark and Skinner canal; 1 of cast iron over slip No. 3; 1 of wrought iron over slip No. 1, and 1 of cast iron over Oak Orchard creek feeder, in Orleans county. The rest of the bridges are on the main line of the Erie canal.

Repairs to Bridges.

Wooden whipple truss bridges Nos. 13 and 37 were rebuilt. Also wooden draw bridge, No. 193, over Scajacquada creek.

Fifty-nine bridges were replanked; and repairs of some kind were made to seventy.

The gearing to Exchange street bridge, No. 73, Rochester, was repaired and trusses strengthened.

New cables were put in the Caledonia avenue, Rochester, lift bridge, No. 76½.

Three new boxes, on line shafting, were put in the West avenue, Rochester, lift bridge, No. 77.

Two new bevel gear wheels were put in Rowe street, Rochester, lift bridge, No. 86.

Bridge No. 101, at Adams' Basin, was raised eight inches.

Trestle work was put under the Scott street, Buffalo, bridge to keep it from falling.

The bridge over the Hamburg canal at Michigan street, Buffalo, No. 214, has been removed and a foot bridge erected until a new bridge be built by the Grade Crossing Commission of Buffalo.

A new farm bridge over the Tonawanda State ditch was built and three others over the same ditch were repaired.

Two spans of wrought iron bridge were erected over Tonawanda creek at Pickardsville.

A wrought iron bridge was erected over Erie canal at Griffith street, Rochester.

Repairs Needed to Bridges.

All wooden bridges should be replaced as soon as possible by iron ones.

A new abutment should be built under the west end of the Scott street, Buffalo, bridge, No. 210. The abutment has slipped and settled, the bridge now being held up by temporary trestle work.

The Pine street bridge, Lockport, No. 161, should have a new abutment on the tow path end, the trusses at present rest on a bench in the natural rock cliff, some twenty-five feet above the tow path. The cliff is rapidly disintegrading, and the trusses, especially the center one, are settling.

A new bridge should replace the present West avenue, Rochester, lift bridge, No. 77. The present bridge is a failure.

New cables were put on the Caledonia avenue, Rochester, lift bridge, No. 76½, this year, but were cut too short and the bridge, when lowered, does not rest on the bridge seats, as it should. New cables should be put in at once.

All bridge abutments, having wing walls with the coping laid on a slant — and nearly all are built that way — are in need of repair. The coping has slipped on the wing walls, in many cases splitting and cracking them. In future it is recommended to step all wing walls.

A law has been passed authorizing the construction of a new bridge at Exchange street, Rochester. The present one, built in 1869, is badly out of repair and should be replaced as soon as possible.

Repairs to Culverts, Stop Gates, Waste Weirs, Etc.

Culvert No. 55, west of Adams Basin, was rebuilt.

Culverts No. 78, east of Ingersoll street, Albion, No. 91, east of Knowlesville, and No. 108, east of Williams bridge, No. 146, were stripped and cemented.

Road culvert, No. 96, east of Beales bridge, No. 136, was braced and the canal bottom over it puddled.

Two new pair of gates were put in the Adams Basin stop gate.

The Cartersville waste weir was braced to prevent its falling.

The Brockport waste weir was retimbered and replanked.

The Holley waste weir, No. 16, Albion waste weir, No. 18, Medina waste weir, No. 20, waste weir No. 22, between Middleport and Orangeport, and Mabee's waste weir, No. 23, were repointed and their gates were repaired.

New gates were put in waste weir No. 24, near Lockport.

About 400 feet of sheeting were put on the canal banks over waste weir No. 22.

Repairs Needed to Culverts, Stop Gates and Waste Weirs.

Nearly all the culverts on the division are in need of repair. The wooden ones should be replaced by stone or by iron pipes. The prism of the canal over the stone culverts should be excavated and the culverts grouted and cemented. Many of the parapet walls have fallen down and need rebuilding.

Road culvert 96 is in especially bad repair, the parapet wall and face wall of the culvert on the north side being held in place by timber bracing. It should be rebuilt at once.

Dive culvert No. 129, which carries the Tonawanda State ditch under the canal, leaks badly and should be repaired.

The Cartersville waste weir is in bad shape. Timber bracing is necessary to keep it from falling. It should be rebuilt as it is unsafe.

Most of the stop gates need new gates.

Repairs to Vertical Walls, Slope Walls and Docking.

East of Rochester, 2,250 lineal feet of docking and 200 lineal feet of vertical wall; in and around Rochester, 1,450 lineal feet of docking and 300 lineal feet of vertical wall; between Rochester and Lockport, 1,340 lineal feet of docking and 560 lineal feet of vertical wall have been rebuilt.

Between Lockport and Buffalo, two miles of docking timber and 500 lineal feet of vertical wall have been put in. In Buffalo, 910 lineal feet of pile docking and 545 lineal feet of vertical wall have been built.

Under Act, chapter 26, Laws of 1895, a vertical wall eighty feet long, at Austin street, Buffalo, was built at the cost of $300.00.

Ditching.

Work has been started on cleaning and improving Beeman's creek, town of Clarence, Erie county, Act, chapter 94, Laws of 1895.

Work has also been started on further improving the sanitary condition of the Genesee Valley canal. This work is being done with the unexpended balance of the money appropriated under Act, chapter 399, Laws of 1893. A ditch 300 feet long, two miles east of Rochester, was excavated in order to prevent damage to land overflowed by canal water.

Bird Island Pier.

This pier, which separates Black Rock harbor from the Niagara river, is very much out of repair. The stone covering has been much damaged by high water and ice, and the cribs have settled and rotted away. Some repairs were made this year by the superintendent, but the whole pier should be carefully relaid. The timber extension of this pier needs a large stone rip-rap protection on its northerly side, estimated quantity, 6,000 cubic yards; recommended in last report.

Erie Basin Breakwater.

About fifty feet of the south end of this breakwater has fallen away. It is recommended that the cribs, piles, etc., left where this portion of the breakwater stood, be taken out and the entrance to the Erie Basin thus widened fifty feet.

All of the repairs, improvements and new work above mentioned have been done by the different section superintendents. Tables further on show what work has been done and what is now going on under contract. All this work is progressing in a satisfactory manner. Considerable difficulty was experienced in getting a suitable foundation for the abutments for the swing bridge at Ohio street, Buffalo. This was due to the uneven nature of the rock surface, and to the fact that the rock was nearer to the water's surface than was supposed. With the aid of a diver, a concrete foundation for the cribs was laid under twenty-five feet of water, and the work is now well under way.

Difficulty was also experienced in making the counter weight pit for the Emerson street, Rochester, lift bridge, water tight.

The leakage, which was through the bottom, was due to the porous and seamy nature of the rock.

Besides getting our plans, estimates and specifications for the work already mentioned, and for that shown in the tables headed "Contracts completed," and "Contracts pending," the same work has been done on the following, which are now ready to be let.

Abating Chemung canal nuisances, Act, chapter 358, Laws of 1894.

Constructing a lift bridge over the Erie canal at Adams street, Lockport, Act, chapter 573, Laws of 1894.

Improving Seneca Lake level of Chemung canal, Act, chapter 572, Laws of 1894.

Deepening and improving the channel of Bull creek, Act, chapter 547, Laws of 1895.

Repairing and reconstructing the banks of Glen creek, Act, chapter 140, Laws of 1895.

Cleaning and repairing Tonawanda State ditch, Act, chapter 19, Laws of 1895.

Deepening and improving Mud creek, Act, chapter 307, Laws of 1895.

Vertical wall on Berme side of Erie canal at Gasport, Act, chapter 476, Laws of 1895.

Dyke on Chemung river bank near Corning, Act, chapter 221, Laws of 1895.

Lengthening the spillway of Cuba reservoir, excavating Divens ditch and rebuilding Divens culvert, strengthening abutments of Chemung river bridge, and improving Oak Orchard creek and canal feeder, Act, chapter 932, Laws of 1895.

Dredging lower Black Rock harbor, Act, chapter 320, Laws of 1895.

Several surveys were made for the board of claims.

No breaks have occurred on this division during the year. Boats have often been delayed during the last summer by getting aground between Buffalo and Lockport. This is caused by the low water in Lake Erie. As this level is fed direct from Lake Erie and its water surface therefore dependent on that of the lake, the only remedy is in deepening the canal.

Water Surface in Lake Erie.

The elevation of the water surface of Lake Erie above the mean low tide is, according to New York State, 572.20; according to the Erie Railway, 571.50; and according to the United States government, 571.875. When work was started on the Ohio basin on April 19, 1895, a water gage was set using the elevation 572.20 as the supposed water surface. Three readings a day were taken on this gage: the average of these readings from April 19 to September 30, 1895, shows the water surface as 570.75. The highest elevation, 571.50, was, on September 27, and the lowest, 570.00, on September 21. Very much greater changes in the water elevation than the one shown here take place, and are due to a long and heavy wind, piling the water up at one end or the other of the lake; but it so happened that no such winds blew during the time that these readings were taken. The fact is shown, however, that the water surface of Lake Erie during the last summer was on an average, 1.45 feet below the elevation used by the New York State engineers in designing all masonry founded on crib or pile foundation. As a result, during all of last summer the tops of these foundations projected above water, and in a comparatively short time, will decay and many costly bridge abutments, piers, etc., will have to be rebuilt. This, of course, if the water does not return, to its former height next year; this is unlikely as the water of the lake has been steadily going down for from four to five years, and if it starts rising next year, will probably take, going on the theory that the lake rises and falls in cycles, the same time to reach its former height of 572.20. The case of the timber foundations remains the same, as if the water surface remain where it is, and it is recommended that a new elevation for the water surface of Lake Erie be assumed at least 1.50 feet below that now used; or better, that the engineer, in designing a structure of the kind mentioned, assume such a water elevation as is obtainable from the records of the preceding year. Such a record should be kept by the State. As a general thing there is work going on in Buffalo that requires a force from office, and in this case no extra expense would be entailed. In any case the expense would be more than justified by the results.

This division has been in charge of John Bisgood, as division engineer, from September 30, 1894, to April 11, 1895, and J. L. Little, from April 25, 1895, to September 30, 1895, with A. T. Jones as resident engineer from September 30, 1894 to September 30, 1895. Mr. Bisgood, after an almost continuous service in the Engineering Department of the State of New York for forty years, died suddenly on April 11, 1895. For twelve years he held the position of resident and for the last five years of his life, that of division engineer, on the western division. By the death of Mr. Bisgood, the State has lost an old and valuable servant.

A statement of the engineering expenses of this division is hereto annexed, showing in detail the names of the persons employed, time of service and compensation of each; also one showing contracts pending and another showing contracts completed and final accounts rendered during the year.

Respectfully submitted,

J. L. LITTLE,

Division Engineer.

STATEMENT giving Names, Rank, Number of Days and Compensation of Engineers upon the Repairs of the Western Division of the New York State Canals, with Incidental Expenses, during the Fiscal Year ending September 30, 1895, from October 1, 1894, to September 30, 1895.

ORDINARY REPAIRS—ERIE CANAL.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
John Bisgood.........	Division engineer...	6 mos. 11 days.	$2,400 00 per year.	$1,272 53
John Bisgood.........	Division engineer...	Expenses	....	155 60
J. L. Little...........	Division engineer...	91 days.........	2,400 00 per year.	598 28
J. L. Little...........	Division engineer...	Expenses	....	225 63
A. T. Jones..........	Resident engineer..	200 days........	2,000 00 per year.	1,097 78
A. T. Jones..........	Resident engineer..	Expenses	....	218 08
W. L. Curtis.........	Assistant engineer..	135¾ days......	5 00 per day..	678 75
W. L. Curtis.........	Assistant engineer..	Expenses	....	95 69
M. W. Wilbur........	Leveler	33½ days.......	5 00 per day..	167 50
M. W. Wilbur........	Leveler	Expenses	....	33 91
M. W. Wilbur........	Leveler	196 days.........	4 50 per day..	882 00
M. W. Wilbur........	Leveler	Expenses	....	106 07
H. A. Van Alstyne...	Leveler	38 days..........	4 50 per day..	171 00
H. A. Van Alstyne...	Leveler	Expenses	....	14 20
J. B. Barrett.........	Rodman	183 days........	3 50 per day..	640 50
J. B. Barrett.........	Rodman	Expenses	....	43 04
Byron R. Salyerds...	Rodman	6 days..........	3 50 per day..	21 00
Byron R. Salyerds...	Chainman..........	27 days.........	2 50 per day..	67 50
Byron R. Salyerds...	Chainman	Expenses	....	10 50
L. B. Fitch..........	Chainman	91 days.........	3 50 per day..	318 50
L. B. Fitch..........	Chainman	Expenses	....	43 47
Guy Miller...........	Chainman	72 days.........	2 50 per day..	180 00
Guy Miller...........	Chainman	Expenses	....	17 69
Henry Geck..........	Chainman	174 days........	2 50 per day..	435 00
Henry Geck..........	Chainman	Expenses	....	70
Walter Dubey........	Chainman	5 days..........	2 50 per day..	12 50
Walter Dubey........	Chainman	Expenses	....	10 44
Wm. Schneider.......	Chainman	5 days..........	2 50 per day..	12 50
Wm. Schneider.......	Chainman	Expenses	....	10 44
				$7,540 80

Incidental expenses.

Stationery	$208 80	
Fuel, light and office rent..	478 52	
Postage and telegraph	71 25	
Telephone	94 00	
Livery	29 50	
Miscellaneous account	212 62	1,094 69
		$8,635 49

EXTRAORDINARY REPAIRS—ERIE BASIN AND DOCKS, BUFFALO.

CHAPTER 224, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
L. B. Fitch..........	Chainman	23 days.........	$3 50 per day...	$80 50
L. B. Fitch.	Chainman	Expenses ...	....	2 88
				$83 38

EXTRAORDINARY REPAIRS—DIVENS DITCH AND CULVERT.

CHAPTER 932, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
H. A. Van Alstyne...	Leveler	19 days.........	$4 50 per day...	$85 50
H. A. Van Alstyne...	Leveler	Expenses	....	7 18
L. B. Fitch..........	Chainman	2 days..........	3 50 per day...	7 00
L. B. Fitch..........	Chainman	Expenses	....	40
James Thomson......	Chainman	15 days.........	2 50 per day...	37 50
James Thomson......	Chainman	Expenses	....	2 40
				$139 98

EXTRAORDINARY REPAIRS — DREDGING LOWER BLACK ROCK HARBOR, BUFFALO.

CHAPTER 820, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
M. W. Wilbur........	Leveler	3 days..........	$5 00 per day...	$15 00
H. A. Van Alstyne...	Leveler	9 days..........	4 50 per day...	40 50
H. A. Van Alstyne...	Leveler	Expenses	....	12 11
L. B. Fitch..........	Chainman	7 days..........	3 50 per day...	24 50
L. B. Fitch..........	Chainman	Expenses	....	6 56
James Thomson......	Chainman	7 days..........	2 50 per day...	17 50
James Thomson......	Chainman	Expenses	....	6 50
Frank Mauerman....	Chainman	6 days..........	2 50 per day...	15 00
Wm. Schneider.......	Chainman	6 days..........	2 50 per day...	15 00
				$152 67

EXTRAORDINARY REPAIRS—BEEMAN'S CREEK.

CHAPTER 94, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
W. L. Curtis.........	Assistant engineer..	6 days..........	$5 00 per day...	$30 00
W. L. Curtis.........	Assistant engineer..	Expenses	....	22 76
J. B. Barrett.........	Rodman	2 days..........	3 50 per day...	7 00
J. B. Barrett.........	Rodman	Expenses	....	6 40
Frank Mauerman....	Chainman	1 day...........	2 50 per day...	2 50
Frank Mauerman....	Chainman	Expenses	....	2 16
James Thomson......	Chainman	3 days..........	2 50 per day...	7 50
James Thomson......	Chainman	Expenses	....	1 18
				$79 50

EXTRAORDINARY REPAIRS—ADAMS STREET LIFT BRIDGE, LOCKPORT.

CHAPTER 573, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
Geo. P. Hilton.......	Plans	....	....	$325 00

EXTRAORDINARY REPAIRS—PILE DYKE AT CORNING.

CHAPTER 556, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
W. L. Curtis	Assistant engineer	20 days	$5 00 per day	$100 00

EXTRAORDINARY REPAIRS—GENESEE VALLEY CANAL NUISANCES.

CHAPTER 399, LAWS OF 1893.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
H. A. Van Alstyne	Leveler	74 days	$4 50 per day	$333 00
H. A. Van Alstyne	Leveler	Expenses		22 20
L. B. Fitch	Chainman	49 days	3 50 per day	171 50
L. B. Fitch	Chainman	Expenses		13 30
				$540 00

EXTRAORDINARY REPAIRS—DITCHES IN TONAWANDA AND AMHERST.

CHAPTER 19, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total. Amount.
A. T. Jones	Resident engineer	32 days	$2,000 00 per year	$173 91
A. T. Jones	Resident engineer	Expenses		92
W. L. Curtis	Assistant engineer	21 days	5 00 per day	105 00
W. L. Curtis	Assistant engineer	Expenses		9 87
H. A. Van Alstyne	Leveler	9 days	4 50 per day	40 50
H. A. Van Alstyne	Leveler	Expenses		4 80
Byron R. Salyerds	Rodman	9 days	3 50 per day	31 50
Byron R. Salyerds	Rodman	Expenses		4 18
L. B. Fitch	Chainman	12 days	3 50 per day	42 00
L. B. Fitch	Chainman	Expenses		13 32
Frank Mauerman	Chainman	10 days	2 50 per day	25 00
Frank Mauerman	Chainman	Expenses		44
Wm. Schneider	Chainman	10 days	2 50 per day	25 00
Wm. Schneider	Chainman	Expenses		44
				$476 88

		$476 88
Incidental expenses.		
Livery	$17 50	
Miscellaneous account	5 62	
		23 12
		$500 00

EXTRAORDINARY REPAIRS—GENESEE VALLEY CANAL NUISANCE.

CHAPTER 399, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total. Amount.
M. W. Wilbur	Leveler	7 days	$5 00 per day	$35 00
M. W. Wilbur	Leveler	Expenses		11 45
J. B. Barrett	Rodman	2½ days	3 50 per day	8 75
J. B. Barrett	Rodman	Expenses		3 82
				$59 02

EXTRAORDINARY REPAIRS—WEST MAIN STREET LIFT BRIDGE, ROCHESTER.

CHAPTER 652, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
Geo. W. Rafter	Expert	Report on movable bridges		$200 00
W. L. Curtis	Assistant engineer	4 days	$5 00 per day	20 00
Casper Scholz	Draughtsman	21 days	3 00 per day	63 00
				$283 00

EXTRAORDINARY REPAIRS—PENDLETON CULVERT.

CHAPTER 17, LAWS OF 1895.

NAME.	Rank	Number of days, etc.	Rate of compensation.	Total Amount.
A. T. Jones	Resident engineer	4 days	$2,000 00 per year	$21 74
A. T. Jones	Resident engineer	Expenses		20 97
J. B. Barrett	Rodman	1 day	3 50 per day	3 50
J. B. Barrett	Rodman	Expenses		2 97
				$49 18

EXTRAORDINARY REPAIRS—MUD CREEK.

CHAPTER 307, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
A. T. Jones	Resident engineer	9 days	$2,000 00 per year	$48 91
A. T. Jones	Resident engineer	Expenses		17 05
W. L. Curtis	Assistant engineer	21 days	5 00 per day	105 00
W. L. Curtis	Assistant engineer	Expenses		70
Byron R. Salyerds	Rodman	26 days	3 50 per day	91 00
Byron R. Salyerds	Rodman	Expenses		35
Frank Mauerman	Chainman	24 days	2 50 per day	60 00
Frank Mauerman	Chainman	Expenses		1 25
Wm. Smith	Laborer	27 days	2 00 per day	54 00
				$378 26

Incidental expenses.

Livery	$94 50	
Miscellaneous account	27 24	
		121 74
		$500 00

EXTRAORDINARY REPAIRS—EXAMINATIONS AND MAPS.

CHAPTER 358, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
J. L. Little..........	Chainman	39 days.........	$2 50 per day...	$97 50
J. L. Little..........	Chainman	Expenses	....	2 14
James Thomson......	Chainman	66 days.........	2 50 per day...	165 00
James Thomson......	Chainman	Expenses	....	6 25
Wm. Schneider.......	Chainman	9 days..........	2 50 per day...	22 50
Wm. Schneider.......	Chainman	Expenses	....	13 88
				$307 27

EXTRAORDINARY REPAIRS—PICKARD'S BRIDGE.

CHAPTER 591, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
A. T. Jones..........	Resident engineer..	18 days.........	$2,000 00 per year.	$98 90
A. T. Jones..........	Resident engineer..	Expenses	....	36 06
W. L. Curtis.........	Assistant engineer..	2 days..........	5 00 per day..	10 00
W. L. Curtis.........	Assistant engineer..	Expenses	....	8 28
J. B. Barrett.........	Rodman	34 days.........	3 50 per day..	119 00
Byron R. Salyerds...	Rodman	105 days........	3 50 per day..	367 50
Byron R. Salyerds...	Rodman	Expenses	....	43 24
L. B. Fitch..........	Chainman	27 days.........	3 50 per day..	94 50
Henry Geck..........	Chainman	15 days.........	2 50 per day..	37 50
Frank Mauerman....	Chainman	27 days.........	2 50 per day..	67 50
Frank Mauerman....	Chainman	Expenses	....	4 60
Dean & Westbrook..	Plans	....	....	275 00
				$1,162 05
Incidental expenses.				
The American Engineering and Inspection Association..........				80 31
				$1,242 39

EXTRAORDINARY REPAIRS—GRIFFITH STREET BRIDGE, ROCHESTER.

CHAPTER 559, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
A. T. Jones..........	Resident engineer..	17 days.........	$2,000 00 per year.	$93 41
W. L. Curtis.........	Assistant engineer..	44 days.........	5 00 per day..	220 00
L. B. Fitch..........	Chainman	34 days.........	3 50 per day..	119 00
Henry Geck..........	Chainman	45 days.........	2 50 per day..	112 50
Henry Geck..........	Chainman	Expenses	....	09
John F. Alden.......	Plans	....	....	150 00
				$695 00
Incidental expenses.				
The American Engineering and Inspection Association..........			$62 00	
Stationery			32 00	
				94 00
				$789 00

EXTRAORDINARY REPAIRS—MAIN STREET BRIDGE, FAIRPORT.

CHAPTER 576, LAWS OF 1894; CHAPTER 151, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
John F. Aldon........	Plans	....	....	$175 00

Incidental expenses.	
Stationery	1 78
	$176 78

EXTRAORDINARY REPAIRS—JERSEY STREET BRIDGE ABUTMENTS, BUFFALO.

CHAPTER 668, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
A. T. Jones..........	Resident engineer..	4 days..........	$2,000 00 per year.	$22 22
A. T. Jones..........	Resident engineer..	Expenses	....	17 15
H. A. Van Alstyne...	Leveler	92 days.........	4 50 per day..	414 00
H. A. Van Alstyne...	Leveler	Expenses	....	13 98
Byron R. Salyerds...	Rodman	36 days.........	3 50 per day..	126 00
Frank Mauerman....	Chainman	21 days.........	2 50 per day..	52 50
				$645 85

EXTRAORDINARY REPAIRS—EMERSON STREET LIFT BRIDGE, ROCHESTER.

CHAPTER 336, LAWS OF 1893; CHAPTER 569, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
J. L. Little...........	Division engineer...	39 days.........	$2,400 00 per year.	$254 35
A. T. Jones..........	Resident engineer..	48 days.........	2,000 00 per year.	262 69
A. T. Jones..........	Resident engineer..	Expenses	....	8 09
W. L. Curtis.........	Assistant engineer..	32 days.........	5 00 per day..	160 00
W. L. Curtis	Assistant engineer..	Expenses	....	15 40
M. W. Wilbur........	Leveler	25 days.........	4 50 per day..	112 50
J. B. Barrett.........	Rodman	15½ days.......	3 50 per day..	54 25
J. B. Barrett.........	Rodman	Expenses	....	20
Byron R. Salyerds...	Rodman	39 days.........	3 50 per day..	136 50
L. B. Fitch..........	Chainman	18 days.........	3 50 per day..	63 00
L. B. Fitch..........	Chainman	Expenses	....	60
Henry Geck..........	Chainman	79 days...	2 50 per day..	197 50
Henry Geck..........	Chainman	....	....	4 76
Geo. P. Hilton.......	Plans	....	....	351 23
				$1,621 07

Incidental expenses.		
The American Engineering and Inspection Association.............	$71 93	
Postage	7 00	
		78 93
		$1,700 00

EXTRAORDINARY REPAIRS—DREDGING OHIO BASIN, BUFFALO.

CHAPTER 145, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
J. L. Little	Division engineer	29 days	$2.400 00 per year.	$189 13
J. L. Little	Division engineer	Expenses		121 83
A. T. Jones	Resident engineer	20 days	2,000 00 per year.	109 42
A. T. Jones	Resident engineer	Expenses		78 45
M. W. Wilbur	Leveler	2½ days	5 00 per day	12 50
M. W. Wilbur	Leveler	Expenses		9 92
J. B. Barrett	Rodman	40½ days	3 50 per day	141 75
J. B. Barrett	Rodman	Expenses		34 83
Byron R. Salyerds	Rodman	50 days	3 50 per day	175 00
D. D. Waldo	Chainman	241 days	4 50 per day	1,084 50
D. D. Waldo	Chainman	Expenses		57 47
Wm. Schneider	Chainman	256 days	2 50 per day	640 00
Walter Dubey	Chainman	303 days	2 50 per day	757 50
Frank Mauerman	Chainman	128 days	2 50 per day	320 00
Dean & Westbrook	Plans			350 00
				$4.082 30
Incidental expenses.				
Fuel and office rent				112 00
				$4,194 30

EXTRAORDINARY REPAIRS—CHEMUNG CANAL NUISANCES.

CHAPTER 726, LAWS OF 1893, CHAPTER 358, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
L. B. Fitch	Chainman	8 days	$3 50 per day	$28 00
L. B. Fitch	Chainman	Expenses		24
				$28 24

EXTRAORDINARY REPAIRS—SURVEY FOR COURT OF CLAIMS.

CHAPTER 932, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
A. T. Jones	Resident engineer	6 days	$2,000 00 per year.	$32 97
A. T. Jones	Resident engineer	Expenses		60
W. L. Curtis	Assistant engineer	6 days	5 00 per day	30 00
W. L. Curtis	Assistant engineer	Expenses		7 48
M. W. Wilbur	Leveler	12 days	4 50 per day	54 00
M. W. Wilbur	Leveler	Expenses		12 68
J. B. Barrett	Rodman	4 days	3 50 per day	14 00
J. B. Barrett	Rodman	Expenses		7 78
Byron R. Salyerds	Rodman	9 days	3 50 per day	31 50
Byron R. Salyerds	Rodman	Expenses		2 60
				$193 61

EXTRAORDINARY REPAIRS—FALL CREEK WALL, HAVANA.

Chapter 345, Laws of 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
John R. Kaley.......	Ass't eng'r in ch'ge	10 days.........	$6 00 per day...	$60 00
John R. Kaley.......	Ass't eng'r in ch'ge	Expenses	....	41 31
W. L. Curtis.........	Assistant engineer..	2¼ days.........	5 00 per day...	11 25
W. L. Curtis.........	Assistant engineer..	Expenses	....	97
H. A. Van Alstyne...	Leveler	27 days.........	4 50 per day...	121 50
H. A. Van Alstyne...	Leveler	Expenses	....	15 07
John Hackett........	Chainman	50 days.........	2 50 per day...	125 00
John Hackett........	Chainman	Expenses	....	26 07
				$401 17

EXTRAORDINARY REPAIRS—CHEMUNG CANAL NUISANCES.

Chapter 726, Laws of 1893.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
L. B. Fitch..........	Chainman	1 day...........	$3 50 per day...	$3 50
L. B. Fitch..........	Chainman	Expenses	....	1 40
				$4 90

EXTRAORDINARY REPAIRS—OAK ORCHARD CREEK AND FEEDER.

Chapter 136, Laws of 1893.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
M. W. Wilbur........	Leveler	31 days.........	$4 50 per day...	$139 50
D. D. Waldo.........	Chainman	72 days.........	4 50 per day...	324 00
D. D. Waldo.........	Chainman	Expenses	....	12 18
George Moreland.....	Chainman	53 days.........	2 50 per day...	132 50
				$608 18

Incidental expenses.

Stationery	$23 50	
Office rent	9 00	
Telegraph	1 92	
Livery	57 00	
		91 42
		$699 60

EXTRAORDINARY REPAIRS—IMPROVING SENECA LAKE LEVEL OF CHEMUNG CANAL.

CHAPTER 572, LAWS OF 1894.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
A. T. Jones..........	Resident engineer..	5 days..........	$2,000 00 per year.	$27 18
A. T. Jones..........	Resident engineer..	Expenses	....	15 52
W. L. Curtis.........	Assistant engineer..	7 days..........	5 00 per day..	35 00
W. L. Curtis.........	Assistant engineer..	Expenses	....	9 02
				$86 72

EXTRAORDINARY REPAIRS—MILL STREET BRIDGE, BUFFALO.

CHAPTER 18, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
Charles F. Stowell...	Plans	....	....	$146 23

EXTRAORDINARY REPAIRS—MAIN STREET BRIDGE, NEWARK.

CHAPTER 217, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
M. W. Wilbur........	Leveler	5 days..........	$5 00 per day...	$25 00
M. W. Wilbur........	Leveler	Expenses	....	2 60
J. B. Barrett.........	Rodman	1½ days........	3 50 per day...	5 25
J. B. Barrett.........	Rodman	Expenses	....	2 60
				$35 45

EXTRAORDINARY REPAIRS—GLEN CREEK, WATKINS.

CHAPTER 140, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total. Amount.
H. A. Van Alstyne...	Leveler	14 days.........	$4 50 per day...	$63 00
H. A. Van Alstyne...	Leveler	Expenses	....	14 83
J. B. Barrett.........	Rodman	2 days..........	3 50 per day...	7 00
J. B. Barrett.........	Rodman	Expenses	....	3 96
L. B. Fitch..........	Chainman	8 days..........	3 50 per day...	28 00
L. B. Fitch..........	Chainman	Expenses	....	11 43
James Thomson......	Chainman	8 days..........	2 50 per day...	20 00
James Thomson......	Chainman	Expenses	....	9 64
				$157 86

EXTRAORDINARY REPAIRS—BULL CREEK

CHAPTER 547, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total. Amount.
W. L. Curtis.........	Assistant engineer..	17 days.........	$5 00 per day...	$85 00
W. L. Curtis.........	Assistant engineer..	Expenses	....	3 21
Byron R. Salyerds...	Rodman	10 days.........	3 50 per day...	35 00
Byron R. Salyerds...	Rodman	Expenses	....	5 27
James Thomson......	Chainman	9 days..........	2 50 per day...	22 50
James Thomson......	Chainman	Expenses	....	1 52
Frank Mauerman....	Chainman	10 days.........	2 50 per day...	25 00
Frank Mauerman....	Chainman	Expenses	....	60
Wm. Schneider.......	Chainman	9 days..........	2 50 per day...	22 50
Wm. Schneider......	Chainman	Expenses	....	60
				$201 20
Incidental expenses.				
Livery				15 00
				$216 20

EXTRAORDINARY REPAIRS—BRIDGE, ETC., FALLS CREEK, MONTOUR FALLS.

CHAPTER 57, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total. Amount.
A. T. Jones..........	Resident engineer..	2 days..........	$2,000 00 per year.	$10 87
A. T. Jones..........	Resident engineer..	Expenses	....	16 05
H. A. Van Alstyne...	Leveler	5 days..........	4 50 per day..	22 50
H. A. Van Alstyne...	Leveler	Expenses	....	16 29
L. B. Fitch..........	Chainman	5 days..........	3 50 per day..	17 50
L. B. Fitch..........	Chainman	Expenses	....	11 14
				$94 35

EXTRAORDINARY REPAIRS—CUBA RESERVOIR SPILLWAY.

CHAPTER 932, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
M. W. Wilbur........	Leveler	2 days..........	$4 50 per day...	$9 00
M. W. Wilbur........	Leveler	Expenses	....	11 10
J. B. Barrett.........	Rodman	8 days..........	3 50 per day...	28 00
J. B. Barrett.........	Rodman	Expenses	....	8 10
				$56 20

EXTRAORDINARY REPAIRS—DYKE AT CORNING.

CHAPTER 221, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total. Amount.
H. A. Van Alstyne...	Leveler	5 days..........	$4 50 per day...	$22 50
H. A. Van Alstyne...	Leveler	Expenses	....	10 45
J. B. Barrett.........	Rodman	22 days.........	3 50 per day...	77 00
J. B. Barrett.........	Rodman	Expenses	....	13 20
L. B. Fitch..........	Chainman	11 days.........	3 50 per day...	38 50
L. B. Fitch..........	Chainman	Expenses	....	16 98
				$178 63

EXTRAORDINARY REPAIRS—SEWER AT HORSEHEADS.

CHAPTER 679, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
John R. Kaley.......	Ass't eng'r in ch'ge	38 days.........	$6 00 per day...	$228 00
John R. Kaley.......	Ass't eng'r in ch'ge	Expenses	....	129 50
M. W. Wilbur........	Leveler	3 days..........	5 00 per day...	15 00
H. A. Van Alstyne...	Leveler	22 days.........	4 50 per day...	99 00
H. A. Van Alstyne...	Leveler	Expenses	....	26 15
L. B. Fitch..........	Chainman	18 days.........	3 50 per day...	63 00
L. B. Fitch..........	Chainman	Expenses	....	23 89
James Thomson......	Chainman	11 days.........	2 50 per day...	27 50
James Thomson......	Chainman	Expenses	....	3 71
				$615 75

EXTRAORDINARY REPAIRS—CHEMUNG RIVER BRIDGE ABUTMENTS AT CHEMUNG.

CHAPTER 932, LAWS OF 1895.

NAME.	Rank.	Number of days, etc.	Rate of compensation.	Total Amount.
H. A. Van Alstyne...	Leveler	3 days..........	$4 50 per day...	$13 50
H. A. Van Alstyne...	Leveler	Expenses	....	5 70
James Thomson......	Chainman	1 day..........	2 50 per day...	2 50
James Thomson......	Chainman	Expenses	....	1 50
				$23 20

SUMMARY OF ENGINEERING EXPENSES UPON THE WESTERN DIVISION NEW YORK STATE CANALS FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 1895.

EXTRAORDINARY REPAIRS.	Authorized by		Amount.
	Chap.	Laws.	
Oak Orchard creek and feeder	136	1893	$699.60
Genesee valley canal nuisances	399	1893	540.00
Chemung canal nuisance	726	1893	4.90
Chemung Canal nuisanse	726 358	1893 1894	28.24
Emerson street lift bridge, Rochester	336 560	1893 1894	1.700.00
Dredging Ohio basin, Buffalo	145	1894	4.194.39
Fall creek wall, Havana	345	1894	401.17
Examinations and maps	358	1894	307.77
Griffith street bridge, Rochester	559	1894	789.00
Pile dyke at Corning	566	1894	100.00
Improving Seneca lake level Chemung canal	572	1894	86.72
Adams street lift bridge, Lockport	573	1894	325.00
Pickard's bridge	591	1894	1,242.39
West Main street lift bridge, Rochester	652	1894	283.00
Jersey street bridge abutments, Buffalo	668	1894	645.85
Main street bridge, Fairport	576 151	1894 1895	176.78
Pendleton culvert	17	1895	49.18
Mill street bridge, Buffalo	18	1895	146.23
Ditches in Tonawanda and Amherst	19	1895	500.00
Bridge, etc., Falls creek, Montour Falls	57	1895	34.35
Beeman's creek	94	1895	79.50
Glen creek, Watkins	140	1895	157.86
Main street bridge, Newark	217	1895	35.45
Dyke at Corning	221	1895	178.63
Erie basin and docks, Buffalo	224	1895	83.33
Deepening, etc., Mud creek	307	1895	500.00
Dredging lower Black Rock harbor, Buffalo	320	1895	152.67
Genesee valley canal nuisances	399	1895	59.02
Bull creek	547	1895	216.20
Sewer at Horseheads	679	1895	615.75
Chemung river bridge abutments at Chemung	932	1895	23.20
Divens ditch and culvert	932	1895	139.98
Cuba reservoir spillway	932	1895	56.20
Survey for Court of Claims	932	1895	193.61
Ordinary repairs	297	1894	8,635 49
Total engineering expenses for western division			$23,440.87

TABLE SHOWING CONTRACTS COMPLETED ON WESTERN DIVISION DURING THE YEAR ENDING SEPTEMBER 30, 1895.

CONTRACTOR.	Date of contract.	Character of work.	LEGISLATIVE ACT.		Appropriation.	Engineer's estimate.	Engineer's estimate at contract price.	Amount of final payment.
			Chap.	Year.				
MacGregor & Hughes	Sept. 25, 1893	Improving Oak Orchard creek and Oak Orchard feeder	136	1893	$35,000 00	$30,200 00	$29,000 00	$27,223 23
A. F. Chapman	July 23, 1894	Abatement of nuisances on Chemung canal at culvert, between Locks No. 1 and 2, at Lock No. 2, and at Falls creek, Havana, N. Y.	726 358	1893 1894	11,500 82	947 00	893 40	884 75
A. F. Chapman	July 23, 1894	Abatement of nuisances on Chemung canal, between Horseheads and Pine Valley, and at Lock No. 26, Millport, and on Chemung canal feeder at East Corning on the lands of Haight, Goff & Gillett	726 358	1893 1894		4,889 00	4,428 90	5,393 62
A. F. Chapman	Aug. 3, 1894	Ditching and rebuilding culverts to abate nuisance on the Chemung canal on lands of A. Diven and others, between Lock No. 48 and Grand Central avenue, Elmira, N. Y.	726 358	1893 1894		4,000 00	4,203 60	4,111 01
Hingston & Woods	July 23, 1894	Improving and dredging Erie basin, Buffalo, N. Y.	588	1894	2,925 00	2,552 40	1,998 00	2,161 14
John Coughlin	July 24, 1894	Vertical wall laid in cement to protect east bank of Falls creek in Havana, N. Y.	345	1894	5,000 00	3,700 00	1,803 00	3,639 38
Michael Bennett	July 26, 1894	Deepening and improving channel of Honeoye outlet in the town of Richmond, Ontario county, N. Y.	563	1893	5,000 00	3,950 00	3,251 00	3,288 28
Brayer & Albaugh	Oct. 27, 1894	Improving sanitary condition of Genesee Valley canal	399	1893	7,500 00	5,660 00	3,580 00	4,913,39
Logie & Leh	Oct. 29, 1894	Substructure for bridge over Tonawanda creek at Pickardsville, N. Y.	591	1894	13,000 00	3,411 00	2,577 00	2,505 92
Wrought Iron Bridge Co.	Dec. 28, 1894	Two spans superstructure for bridge over Tonawanda creek at Pickardsville, N. Y.	591	1894		5,000 00	4,175 00	5,267 00
B P. Smith	Dec. 24, 1894	Substructure for bridge over Erie canal at Jersey street, Buffalo, N. Y.	668	1894	*10,000 00	5,709 00	4,920 00	4,972 06

TABLE SHOWING CONTRACTS COMPLETED ON WESTERN DIVISION DURING THE YEAR ENDING SEPTEMBER 30, 1895.—*Continued.*

CONTRACTOR.	Date of contract.	Character of work.	LEGISLATIVE ACT.		Appropriation.	Engineer's estimate.	Engineer's estimate at contract price.	Amount of final payment.
			Chap.	Year.				
Rochester Bridge and Iron Wks.	Dec. 26, 1894	Superstructure for bridge over Erie canal at Griffith street, Rochester, N. Y.	559	1894	8,500 00	5,000 00	4,175 00	4,189 47
B. P. Smith	Dec. 27, 1894	Substructure for bridge over Erie canal at Griffith street, Rochester, N. Y.	559	1894		2,592 00	1,912 00	2,519 69
Sayles & McGiven	Jan. 2, 1895	Pile dyke on east side of Chemung river in Corning, N. Y.	566	1894	996 32	700 48	777 88	793 59
B. P. Smith	Feb. 16, 1895	Substructure for bridge over Erie canal at Emerson street, Rochester, N. Y.	336 560	1893 1894	†17,000 00	4,075 25	3,753 95	‡7,257 02

*This amount includes removal of bridge at Porter ave. See "Contracts pending." †This amount includes construction of superstructure. See "Contracts pending." ‡Increase due to change in plan on account of bad foundation.

TABLE SHOWING CONTRACTS PENDING ON THE WESTERN DIVISION, SEPTEMBER 30, 1895.

CONTRACTOR.	Date of contract.	Character of work.	LEGISLATIVE ACT.		Appropriation.	Engineer's estimate.	Engineer's estimate at contract price.	Amount of payments to date.
			Chap.	Year.				
Logie & Leh	Dec. 26, 1894	Taking down bridge at Porter ave., Buffalo, re-erecting same at Jersey st., and lengthening sidewalk brackets on same.	668	1894	*$10,000 00	$1,000 00	$946 25	....
Buffalo Dredging Co	Dec. 28, 1894	Dredging and docking in Ohio basin and slip and substructure for swing bridge over entrance to same in Buffalo, N. Y.	145	1894	60,000 00	43,297 00	36,328 00	$27,018 00
Wrought Iron Bridge Co	Dec. 28, 1894	Swing bridge over entrance to Ohio basin at Ohio st., Buffalo, N. Y.	145	1894		8,217 00	5,624 00	2,397 00
Wrought Iron Bridge Co	Feb. 18, 1895	Lift bridge over Erie canal at Emerson st., Rochester, N. Y.	336 560	1893 1894	†17,000 00	9,974 27	9,940 00	5,066 00
Chambers & Casey	May 9, 1895	Substructure for bridge over Erie canal at Main st., Fairport, N. Y.	576 151	1894 1895	6,500 00	6,044 00	5,198 00	....
Hilton Bridge Co	July 27, 1895	Substructure and superstructure for bridge over Erie canal at Mill st., Buffalo, N. Y.	18	1895	9,500 00	6,440 00	6,944 60	....
J. J. Churchyard	Aug. 8, 1895	Docking and dredging in Erie basin, Buffalo, N. Y.	224	1895	5,378 00	4,473 40	4,321 90	....
R. E. Beardsley	Aug. 24, 1895	Brick sewer in Horseheads, N. Y., from intersection of Chemung canal feeder with summit level of Chemung canal to New Town creek	679	1895	10,000 00	7,420 25	6,984 50	3,111 00
Frank J. Le Valley	Sept. 11, 1895	Ditch and iron culvert to drain land in town of Pendleton, Niagara Co., N. Y.	17	1895	2,000 00	1,819 00	1,780 05	....

*This amount includes construction of substructure at Jersey street. See "Contracts completed." †This amount includes construction of substructure. See "Contracts completed."

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